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GRUMMAN AIRCRAFT ENGINEERING CORPORATION

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This specification supersedes LSP-280-4A dated 11-12-63.

SPECIFICATION

No. LSP-280-4B Date: 7-8-64

PROPELLANT TANK ASSEMBLY

DESCENT STAGE

DESIGN CONTROL SPECIFICATION FOR [redacted]

Contract No. NAS 9-1100

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Grumman LEM

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Rev.	Date	REVISION DESCRIPTION	
A	11/12/63	Revised to incorporate all changes negotiated with the vendor.	
B	7/8/64	Revised to incorporate Amendments number 1 through 5 to Revision A. Changes are indicated by marginal indicia.	

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PROPELLANT TANK ASSEMBLY

DESCENT STAGE

DESIGN CONTROL SPECIFICATION FOR

1 SCOPE

1.1 Scope. - This specification establishes design, fabrication, performance and quality assurance requirements for Propellant Tank Assemblies to be used in the Lunar Excursion Module (LEM), Descent Stage, of the Apollo Spacecraft.

2 APPLICABLE DOCUMENTS

2.1 Government Documents. - The following Government documents of issue in effect on 14 January 1963, or as otherwise specified, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Federal

BB-N-411	Nitrogen

Military

MIL-P-26539A	Propellant, Nitrogen Tetroxide
MIL-P-27402	Propellant, Hydrazine - uns - Dimethylhydrazine (50% N_2H_4 - 50% UDMH)
MIL-A-18455B	Argon, Technical
MIL-T-9046C	Titanium and Titanium Alloys Sheet, Strip and Plate

2.1 (Continued)

MIL-I-6866A	Inspection; Penetrant, Method of A
MIL-T-9047C	Titanium and Titanium Alloys, Bars, Forgings and Forging Stock

STANDARDS

Federal

FED-STD-151a Change Notice 4 Nov. 28, 1962	Metals, Test Methods
MIL-STD-10A	Surface Roughness and Waviness of Lay
MIL-STD-12B	Abbreviations for Use on Drawings
MIL-STD-810(USAF) (dated 14 June 1962)	Environment Test Methods for Aerospace and Ground Equipment
MIL-STD-453	Military Std Inspection, Radiographic

2.2 Grumman Documents. - The following Grumman documents of date of issue shown form a part of this specification to the extent specified herein.

Specifications

LSP-270-0001	Cleanliness Level Requirements For The Propulsion Subsystem, (Ascent and Descent Stage)
LSP-390-001	Bonding Electrical, General Specification for

2.2 (Continued)

Drawings

LSC280-400 Revision D	Propellant Tank Assembly, Descent Stage, Specification Control Drawing for
LSC280-401 Revision E	Tank Subassembly, Descent Stage, Specification Control Drawing for
LSC280-402B	Baffle Subassembly, Descent Stage, Specification Control Drawing for
LSC280-403B	Cover Subassembly, Descent Stage, Specification Control Drawing for

2.3 Other Documents. - The following documents, issued by the organization indicated and of the data of issue shown, form a part of this specification to the extent specified herein.

Helium Grade A Bulletin 585	U.S. Dept of Interior Bulletin 585
AMS 4088E	Tubing, Seamless, Drawn, 4.5 Cu - 1.5 Mg - 0.6 Mn (2024-T3)
AMS 4035D	Sheet and Plates 4.5 Cu - 1.5 Mg - 0.6 Mn (2024-0)
AMS 4951	Aeronautical Material Specification Titanium Wire
AMS 4029	Aeronautical Material Specification Aluminum Alloy Sheet & Plate 4.5 Cu - 0.85; - 0.8Mn - 0.5Mg. (2014.T6)
SAE-ARP-598	Procedure for the Determination of Particulate Contamination by the Particle Count Method

2.4 Availability of Documents. -

2.4.1 Government Documents. - Copies of Government documents may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

2.4.2 Grumman Documents. - Copies of this specification and other applicable Grumman documents may be obtained from LEM Program Data Management, Grumman Aircraft Engineering Coporation, Bethpage, Long Island, New York.

2.4.3 Other Documents. - Copies of other documents may be obtained from the appropriate organization listed in 2.3.

3 REQUIREMENTS

3.1 General. - The Propellant Tank Assembly covered by this specification shall:

(a) Be capable of storing MIL-P-26539 Nitrogen Tetroxide (N_2O_4) Propellant.

(b) Be capable of storing MIL-P-27402 Hydrazine - uns - Dimethylhydrazine (50% N_2H_4 and 50% UDMH) Propellant.

(c) Be capable of being pressurized with helium.

(d) Maintain the stored propellants at the prescribed levels of quality, safety and useability under all conditions and for the time intervals specified in Table I.

3.2 Subassemblies. - The Propellant Tank Assembly (LSC280-400) shall consist essentially of the following major items and attaching hardware.

3.2 (Continued)

Tank Subassembly	(LSC280-401)
Baffle Subassembly	(LSC280-402)
Cover Subassembly	(LSC280-403)
Skirt Subassembly	(Interface or LSC280-400)

3.2.1 Details of Subassemblies. -

3.2.1.1 Tank Subassembly. - The Tank Subassembly shall consist of two (2) machined tank halves welded together. The halves shall be machined from forgings of titanium in accordance with 3.16.1.1. The forgings, and the billets they are forged from shall meet the requirements of Table II and shall in addition be uniform in quality and condition, free from surface and sub-surface defects, laps, seams, pipe, slivers, scales, slag, porosity, cracks, hard spots and all other defects which may prevent the tanks from meeting the requirements of this specification. The configuration of the Tank Subassembly shall be as shown on Specification Control Drawing LSC280-401.

3.2.1.2 Baffle Subassembly. - The baffle design including selection of materials and method of attachment to the Tank Subassembly shall be consistent with the requirements of this specification and shall result in a minimum Propellant Tank Assembly weight. The required configuration of the Baffle Subassembly shall be as shown on Specification Control Drawing LSC280-402.

3.2.1.3 Cover Subassembly. - The Cover Subassembly shall consist of the cover, zero-"g" can, vortexing device, seal and provisions for mounting quantity, temperature and pressure monitoring equipment located inside the tank. Provisions for attaching helium and propellant plumbing to the tank shall also be incorporated in the Cover Subassembly. Configuration shall be in accordance with Specification Control Drawing LSC280-403 and shall accommodate the Cover Seal and attaching hardware.

3.2.1.3.1 Cover. - The Cover shall be a machined forging of titanium in accordance with 3.16.1.1. The forging and the billet it is made from shall meet the requirements of Table II and shall in addition, be free from surface and sub-surface defects, laps, seams, pipe, silvers, scales, slag, porosity, cracks, hard spots and all other defects.

3.2.1.3.2 Cover Seal. - The cover seal shall be fabricated from a material which is compatible with the propellants. The seal and the accommodations for the seal shall permit it to function to design requirements by the clamp-up action of the cover bolts and without the use of adhesives or other additional sealing preparations.

3.2.1.3.3 Zero "G" Can and Vortexing Device. - The zero "g" can and vortexing device shall be made of titanium.

3.2.1.4 Skirt Subassembly. - The Skirt Subassembly will be made of AMS 4029 Aluminum Alloy 2014-T6 and will be supplied by Grumman.

3.2.1.4.1 Skirt Subassembly Interface. - The interface of the skirt subassembly with the tank subassembly is shown on LSC280-400C. This interface shall provide for a minimum of one (1) removal and re-attachment operation. Compliance with dissimilar metals requirements of 3.16.1.2 for the interface, shall be a requirement of the Tank Subassembly design.

3.3 Installed Position. - The Propellant Tank Assembly will be oriented in the Lunar Excursion Module (LEM) in a position relative to the spacecraft axes shown by coordinates on Specification Control Drawing LSC280-400.

3.4 Tank Support Provisions (In LEM). - The Propellant Tank Assembly will be mounted and supported as shown in LSC280-400.

3.5 Environmental Conditions. - The Propellant Tank Assembly shall operate within the requirements specified herein during and after exposure to the environmental conditions specified in Table III. All structural loads shall be multiplied by the applicable yield safety factor of paragraph 3.7. The design shall consider all rational combinations of these conditions.

3.5.1 Radiation Environment. - Charged particle and electromagnetic radiation, present in cislunar space, originating from the Van Allen Belts, solar flares and space background shall be considered in the design. A detailed description of this environment will be provided by Grumman where it is necessary to evaluate overall reliability.

3.6 Reliability. -

3.6.1 Mission Success and Safety. - The probability of success and the probability of safety goals are equal and shall be (.999995) for completion of the mission requirements specified herein. The goal shall include all operating and nonoperating phases of life specified in Table I.

3.6.2 Operational Profile. - The reliability requirements above shall be based on time and environmental parameters specified in Table III.

3.6.3 Reliability Apportionment. - The Propellant Tank Assembly and its subassemblies and parts shall be designed to meet the reliability apportionment as developed by the reliability studies required by the Purchase Order. The predicted reliability of each subassembly and part shall be equal to or greater than the required reliability as determined by the studies.

3.6.4 Derating. - Design values shall be derated in accordance with the factors developed in the reliability studies specified.

3.7 Structural Design Criteria. - The Structural Design Criteria specified below shall be applied to the Propellant Tank Assembly. The design shall incorporate positive margins of safety for the specified loading conditions when increased by the applicable factors of safety.

3.7.1 Strength, Stiffness, and Limit Load. - The level of structural strength and stiffness shall be established by rational analyses to meet the specified loading conditions. The loading conditions of the following paragraphs and Table III are limit loads with the exception of the vibration spectra, see paragraph 3.7.6. For design, these limit loads shall be multiplied by the appropriate factor of safety specified herein. Rational allowance shall be made and incorporated in the limit loads for at least the following:

(a) Stress concentration

(b) Fatigue

(c) Dynamic response

(d) Vibrational amplification

3.7.2 Pressure Stabilization. - The tank structure shall not require pressure stabilization. When pressure loads are relieving in conditions involving the combination of uniform internal pressure with acceleration forces, pressure shall not be used.

3.7.3 Yield Factor of Safety. - The yield factor of safety shall not be less than 1.33. This factor of safety shall be increased in weld areas as required in paragraph 3.7.7. At limit load times the yield factor of safety there shall be no permanent deformation which could prevent the Propellant Tank Assembly from complying with the requirements of this specification.

3.7.4 Ultimate Factor of Safety. - The ultimate factor of safety shall not be less than 1.5. This factor of safety shall be increased in weld areas as required in paragraph 3.7.7. At limit load times the ultimate factor of safety there shall be no structural failures.

3.7.5 Proof Pressure Factor. - The proof pressure factor shall be 1.33 applied to the design internal pressure specified in paragraph 3.7.9. During and after exposure to proof pressure, the tank shall be fully capable of meeting the requirements of this specification.

3.7.6 Vibration Design Factors. - The applied vibrational environment given in Table III for launch and boost, translunar, and lunar descent phases of the mission consists of random excitation up to 2000 cps. The high acceleration density levels at low frequencies are presented for use in design analysis only since available test equipment is incapable of reproducing the complete spectrum. The test requirements of Table IV include separate sinusoidal vibrations to account for this low frequency portion of the random spectrum as well as to determine the design adequacy in individual vibration modes. See test requirements of paragraph 4.3.8 and Table IV (Qualification Test Conditions) for test procedures and times. The ultimate vibrational values given in Table IV shall be considered as part of the vibrational design.

For structural limit and ultimate loads, the following factors of safety shall be applied to the vibration amplitudes of Table III.

3.7.6.1 Limit Loads. -

(a) Pre-launch packaged and unpackaged sinusoidal levels: 1.0 applied to g and double amplitude.

3.7.6.1 (Continued)

(b) Launch, boost, translunar, descent sinusoidal levels: 1.3 applied to g and double amplitude.

(c) Random levels during all phases: $(1.3)^2$ applied to g^2/cps.

3.7.6.2 Ultimate Loads. -

(a) Pre-launch packaged and unpackaged sinusoidal levels: 1.5 applied to g and double amplitude.

(b) Launch, boost, translunar, descent sinusoidal levels: 1.5 applied to g and double amplitude.

(c) Random levels during all phases: $(1.5)^2$ applied to g^2/cps.

3.7.6.3 Vibration Amplification Factor. - The vibration amplification factor of the design shall not exceed 10 over the vibrational ranges specified in Table III. This factor shall be defined as the total displacement of any point divided by the displacement at the input points.

3.7.7 Weld Factor. - For design of welded joints, the stresses due to the design internal pressure of paragraph 3.7.9 shall be increased by a weld factor of 1.33 above those obtained when the factors of paragraph 3.7.3 and 3.7.4 are applied. The resulting stresses shall not exceed the allowable stresses specified in paragraphs 3.16.3.2.8 (at welds).

3.7.8 Environmental Factors. - The factor of safety for design, proof and ultimate shall be equal to 1.0 for the following environments listed in Table III.

3.7.8 (Continued)

(a) Humidity
(b) Rain
(c) Salt Spray and Fog
(d) Sand and Dust
(e) Fungus
(f) Ozone
(g) Hazardous Gases
(h) Radiation

3.7.9 Design Internal Pressure. - The limit design internal pressure is 270 psia. This pressure results from the fluid expulsion system and is based on the system relief valve pressure setting.

3.7.10 Ullage Volume Pressure. - The limit value of this pressure can vary from 15 to 120 psia and results from the propellant loading back pressure. Variations in pressure are due to temperature variations of the fluid enclosed in the tank. This pressure is not additive to the design internal pressure of paragraph 3.7.9.

3.7.11 Hydrostatic Pressure. - Hydrostatic pressure and inertia forces shall be based on a fluid density of .0525 lbs/in^3.

3.7.12 Design Accelerations. - Limit values of design accelerations are specified in Table III. Design conditions based on combinations of these accelerations and the pressure of paragraph 3.7.10 are given in Table III.

3.7.13 Leakage. - The total leakage rate of the Propellant Tank Assembly shall not exceed 10^{-3} cc/sec when the tank is pressurized, at $70^{\circ} \pm 20^{\circ}F$, with helium at 15 psia and then at 270 psia.

3.7.14 Baffle Stiffness. - The baffles and baffle assembly installation within the tank structure shall be designed with sufficient stiffness or clearances so that, under the conditions specified in Table III there shall be no physical damage to the tank or pyrophoric reaction.

3.7.14.1 Baffle Design Conditions. - The limit design loads for the baffles shall be based on a differential pressure equal to an equivalent head of fluid. The maximum value of the fluid head for the load distributions considered are specified in Figure 3. Ring baffle and support frame identification are specified in Figure 2. The following conditions shall be considered in design. For each condition all loading cases specified are applied simultaneously.

Condition 1A:

Loading Case 1. on Ring Baffle I
Loading Case 2. on Ring Baffle II
Loading Case 3. on Support Frames between Ring Baffles I & III

Condition 1B:

Loading Case 1. on Ring Baffle I
Loading Case 2. on Ring Baffle II
Loading Case 3. on Support Frames between Ring Baffles I & III

Condition 2A:

Loading Case 1. on Ring Baffle II
Loading Case 2. on Ring Baffle III
Loading Case 3. on Support Frames between Ring Baffles II & IV

Condition 2B:

Loading Case 1. on Ring Baffle II
Loading Case 2. on Ring Baffle III
Loading Case 4. on Support Frames between Ring Baffles II & IV

Condition 3A:

Loading Case 1. on Ring Baffle III
Loading Case 2. on Ring Baffle IV
Loading Case 3. on Support Frames between Ring Baffle III and Baffle-Tank Support Plane

3.7.14.1 (Continued)

Condition 3B:

Loading Case 1. on Ring Baffle III
Loading Case 2. on Ring Baffle IV
Loading Case 4. on Support Frames between Ring Baffle III and Baffle-Tank Support Plane

Condition 4A:

Loading Case 1. on Ring Baffle IV
Loading Case 3. on Support Frames Between Ring Baffle IV and Baffle-Tank Support Plane

Condition 4B:

Loading Case 1. on Ring Baffle IV
Loading Case 4. on Support Frames Between Ring Baffle IV and Baffle-Tank Support Plane

3.8 Capacity. - The propellant capacity of the tank including ullage volume shall be no less than 98,119 cubic inches at 65^{o}F, as shown in the following table.

Item	Volume Required cubic inches
Propellant Volume	98,119
Ullage Volume	Included in propellant volume above.
Measurement Equipment Allowance (Quantity, Temperature and Pressure Monitoring)	150
Baffle Volume	Not included in propellant volume above
Total Required Internal Volume	98,269 plus baffle volume

3.9 Residual Fluids. - The Propellant Tank Assembly shall incorporate design features which shall keep residual fluids to an absolute minimum when in the installed position.

3.10 Bonding. - Bonding shall be in accordance with requirements of LSP-390-001.

3.11 Fail Safe. - Design shall be such that part failures shall not propogate sequentially, i.e., the design shall be "fail-safe".

3.12 Interchangeability. - Items designated as interchangeable shall be capable of being interchanged or substituted, any one for another, without modification or selection, and will provide the same design, engineering and physical and functional characteristics required of the original items and will require no modification of any assembly or system in which either may be used.

3.12.1 Interchangeable Items. - The following listed items covered by this specification shall be interchangeable:

(a) Propellant Tank (Assembly)

(b) Tank Subassembly (except at skirt interface attaching hardware)

(c) Cover Subassembly

(d) Cover Seal (initial installation only)

(e) Bolts, Cover Subassembly

(f) All removable detail parts which are physically similar

3.13 Replaceability. - Items designated as replaceable shall meet all the requirements of interchangeable items except that operations such as drilling, filing, polishing, etc., may be required in the process of replacement. "Replaceable" shall include replacement of an item which was previously installed or replacement with a new item.

3.14 Maintainability. - The design shall include connections, fittings, and similar items which may be disassembled as well as access to them and access for replacement of assemblies, servicing, and adjustment. These features shall be subject to Grumman approval and shall be provided as shown necessary by the Reliability Analysis and the Maintainability Analysis, performed during preliminary design stages as required by the Purchase Order.

3.15 Accessibility. - Access shall be provided for installation, inspection and maintenance of the Propellant Tank Assembly. Access shall require a minimum of disassembly or displacement of parts, readjustments, resealing, reinspecting, special tools or equipment.

3.16 Materials, Parts, and Processes. - Materials, parts and processes shall be selected to meet detailed requirements determined by design analysis based on function, reliability and the environment generated by operation of the unit, as well as the conditions specified herein. Materials, parts, and processes shall be subject to Grumman approval.

3.16.1 Materials. -

3.16.1.1 Titanium Alloy. - All titanium parts specified herein shall be made of a material which, as a minimum, meets with the requirements of MIL-T-9047C Class 5 or MIL-T-9046C Class 2. When other requirements of this specification impose higher or more stringent requirements, then the highest or most stringent requirements shall govern.

3.16.1.2 Dissimilar Metals. - Dissimilar metals shall not be used in contact with each other, unless suitably protected against electrolytic and chemical corrosion or deterioration to the extent that no contamination or operational impairment is added to the system for the life of the part. The fluids and environmental conditions specified herein shall be considered when determining the existence of an undesirable dissimilar metal combination.

3.16.2 Parts. -

3.16.2.1 Limited Life Items. - The use of parts whose life is anticipated to be less than the required life of the Propellant Tank Assembly shall be avoided. When this type of part must be used, the part shall be marked to indicate date of manufacture and the anticipated end of useful life either by date or number of duty cycles or both.

3.16.2.2 Fastening Devices. - All fastening devices, including those with self locking features, shall incorporate positive safetying provisions. Fastening devices which place threads in bearing shall not be used.

3.16.2.2.1 Cover Attaching Bolts. - The bolts used to attach the Cover Assembly to the tank Subassembly shall have an anti-gall coating and other necessary features to insure proper installation without damage to threaded portions of the tank or the bolt.

3.16.3 Processes. -

3.16.3.1 Fabrication and Heat Treat Processes. - Specific fabrication and heat treat processes employed to meet the requirements of this specification shall be establised and recorded. These processes shall include but are not limited to the following:

(a) Annealing and stress relieve temperatures

(b) Preheat cycle

(c) Solution anneal cycles

(d) Aging cycle

(e) Quench media and time

(f) Furnace atmosphere

(g) Tooling and fixtures

(h) Process, practice, and controls to be used

(i) Capability demonstration - distortion control and correction, metallurgical and mechanical properties.

3.16.3.2 Welding. - All welding of the tank sub-assembly shall be performed by Grumman approved methods of mechanized tungsten (TIG) inert gas process using an inert gas chamber or equivalent local inert gas shielding. Criteria for approval shall be in accordance with Section 4 of this specification.

3.16.3.2.1 Type of Weld. - Only butt welds shall be permitted.

3.16.3.2.2 Inert Shielding Gas. - Inert gas used for shielding shall be:

(a) Argon in accordance with MIL-A-18455B.

(b) Helium Grade A in accordance with U.S. Department of Interior Bulletin 585.

(c) Any combination of (a) and (b) of a grade specifically designated for welding, and with a maximum dew point of -65°F.

3.16.3.2.3 Filler Wire. - Filler wire used for welding shall be commercially pure Titanium in accordance with AMS4951.

3.16.3.2.4 Mismatch. - The allowable mismatch of welded sections shall be 0.010 inch maximum before welding.

3.16.3.2.5 Weld Bead. - The width of the weld bead shall be no greater than 4 times the wall thickness of the tank at any weld joint. The maximum buildup of the weld bead shall be equal to or less than 0.045 inch on the O.D. and 0.030 inch on the I.D.

3.16.3.2.6 Penetration. - Complete 100% penetration shall be achieved throughout the length of the weld.

3.16.3.2.7 Planishing. - Weld beads shall not be planished. Grinding, machining, scarfing, or repair of the final face or the root bead may be done only with the permission of Grumman.

3.16.3.2.8 Material Properties. - Uniaxial material properties of heat treated tanks and covers, as determined by room temperature examination of test coupons, shall be in accordance with the following requirements:

	(Tank and Cover) Parent Material	(Tank Only) Transverse At Welds	(Tank Only) Longitudinal At Welds
Ultimate strength (psi) min.	165,000	130,000	155,000
Yield strength 0.2% offset (psi) min.	155,000	120,000	145,000
Elongation (% in 1 inch)	8	4	5
Reduction of area % min.	10	-	-

3.16.3.2.9 Stress Relieving. - All welds shall be aged or stress relieved, or both.

3.16.3.2.10 Rework Procedure. - Should weld discontinuities be detected in excess of the requirements of 4.4.1.1.5, the defective areas shall be repair welded using the procedure developed in paragraph 4.4.1.1.4. No more than two repairs shall be permitted in the same area.

3.16.3.3 Other Weldments. - Manual welding is permitted provided welding is performed in an inert gas chamber or equivalent having adequate controls to insure sound welds. Inert gas shall conform to paragraph 3.16.3.2.2. Welding shall be performed by certified welders. Visible cracks of any kind in weld metal or parent metal shall not be acceptable. All welds shall be inspected by fluorescent penetrant method.

3.17 Finish. -

3.17.1 Interior. - None

3.17.2 Exterior. - None

3.18 Dimensions. - Dimensions shall be as shown on applicable Specification Control Drawings noted herein.

3.18.1 Tolerances. - Tolerances shall not exceed those specified on the applicable Specification Control Drawings.

3.19 Weight. - The maximum Propellant Tank Assembly weight shall be 118.1 pounds.

3.20 Surface Roughness. - Surface roughness shall be established for all interior and exterior surfaces and specified in accordance with MIL-STD-10A. Values established on Specification Control Drawings LSC280-401 and LSC280-403 shall not be exceeded.

3.21 Cleanliness. - The interior of the Propellant Tank Assembly shall meet the cleanliness requirements of LSP-270-0001 when tested in accordance with paragraph 4.4.3.2.2.6. The tank shall then be packaged and sealed in a manner that the cleanliness level will be maintained under all prelaunch conditions until used.

3.21.1 Cleaning Process. - The cleaning process shall not impair the cleanliness status or other requirements of the Propellant Tank Assembly. Caution should be used during acid cleaning treatments in order to ensure against hydrogen pickup.

3.21.2 Marking. - Each Propellant Tank Assembly which has been tested and approved as clean in accordance with 3.21 shall have a suitable permanent warning marking attached to the outside of the cover subassembly stating "OPEN IN CLEAN AREA ONLY".

3.22 Marking and Identification. - The Propellant Tank Assembly and its subassemblies, and parts shall be marked and identified as specified below:

3.22.1 Identification Terms. -

3.22.1.1 Nomenclature. - Nomenclature shall be the same as the approved title of the specification or drawing to which the item is designed. In all instances, the principal identifying noun or noun phrase shall appear first. Where limitation of space precludes spelling out the entire title, it may be abbreviated to the following extent: the principal noun or noun phrase shall be spelled out and the significant modifiers (which establish accurate identification) abbreviated per MIL-STD-12B.

3.22.1.2 Design Control Number. - This number is used to identify design control documents (e.g.: Grumman or vendor specification number). It is assigned by the design activity whose specifications and engineering drawings control the design and production of an item.

3.22.1.3 Serial Number or Lot Number. - Serial or lot number assignment shall be established by procedure subject to Grumman approval. These numbers shall be unique and consecutively assigned to items bearing the identical manufacturer's part number.

3.22.1.4 Contract Number. - The contract number (NAS 9-1100) identifies the NASA/Grumman contract for the LEM. This number shall be marked on all items. Items purchased or subcontracted by Grumman, shall, in addition, be marked with the applicable Purchase Order (P.O.) number.

3.22.1.5 Manufacturer's Part Number. - The manufacturer's part number shall be the number identifying the drawing (including dash number(s) if the drawing is tabulated or multidetail) to which an item is actually manufactured. Number assigned to identify sales, outline, installation, specification control or purchase control drawings for procurement of items by contractors shall not be used as the manufacturer's part number. An item shall always be identified by the part number assigned by the manufacturer throughout its life, regardless of where used.

3.22.1.6 Manufacturer's Name, Trademark or Code Symbol. - The name, trademark or code symbol entered shall be that of the activity who establishes and is responsible for the Manufacturer's identification, provided it is clearly separated therefrom by a dash, slash, parentheses, or other suitable means.

3.22.1.7 Special Characteristics and Information. - Under this heading pertinent rating, operating characteristics, assembly date and other information necessary for identification, if any, may be entered. (See paragraph 3.16.2.1.)

3.22.1.8 U.S. - The notation "U.S." shall denote Government ownership. Other notations such as USA, NASA, or LEM shall not be used.

3.22.2 Identification Data Requirements. - All items shall be identified in accordance with this specification prior to being subjected to their quality assurance requirements. The following identification data shall apply to all items:

Nomenclature

Design Control No. 5 (The applicable Grumman Specification Control Drawing No. and dash no.)

Serial Number

Contract Number

Manufacturer's Part Number

Manufacturer's Name, Trademark or Code Symbol

Special Characteristics (when applicable)

U.S. (Notation)

3.22.3 Location of Nameplate or Markings. - Wherever possible, the nameplate or marking shall be visible and readable after the item is assembled or installed.

3.22.3.1 Identification of Items Without Suitable or Sufficient Marking Surface. - Items which do not have suitable or sufficient surface to reflect the complete identification data shall, as a minimum, be identified with the manufacturer's part number and the serial or lot number. Where this is not possible, the item shall be accompanied by suitable means of identification subject to Grumman approval.

3.22.3.2 Identification of Unmarked Items Subject to Removal After Installation. - The identification of unmarked items subject to removal after installation shall be applied to the item to which the unmarked item is assembled. This marking shall be on a surface adjacent to the unmarked item when assembled.

3.22.3.3 Items Intended for Permanent Installation. - Items which lose their identity after installation (e.g.: items installed by welding and non-removable hardware) shall not be reidentified.

3.22.4 Reworked or Selected Items. - Items reworked or selected for special fit, performance or tolerance shall require new or supplemental identification data as specified in 3.22.2.

3.22.5 Methods of Marking. - Identification of items shall be accomplished by marking methods, materials and nameplates which will not adversely affect the life or utility of the items to which they are applied. All markings shall be capable of withstanding the environmental and life expectancy of the item to which they are attached, and shall be permanent and legible for ready identification. Metal stamps or electric stenciling shall not be used on finished hardware.

3.22.5.1 Selection of Materials and Methods of Application. - Identification shall be accomplished by one of the following methods:

(a)	Nameplates	Attached by a method allowing alteration of data without requiring retesting per Section 4.
(b)	Stencil or decalcomania transfer	Applied over exterior finish and removable or otherwise alterable without affecting the exterior finish.
(c)	Acid or electric	Shall be located where obliteration and additional markings may be added without testing.

3.23 Workmanship. - All phases of workmanship shall be performed in a thoroughly workmanlike manner in accordance with the applicable drawings, specifications, and standards. Processes and manufacturing methods, not covered by specifications shall be entirely suitable for the article, and workmanship shall be in accordance with high grade spacecraft practice. The quality of workmanship shall not degrade the reliability, performance, and life inherent in the design of the article. All surfaces shall be smooth and free from porosity, burrs, chips, dents, and other irregularities.

4 QUALITY ASSURANCE PROVISIONS

4.1 General. - This section of the specification establishes the general test and inspection requirements to be followed during the propellant tank test program. The program shall consist of the following test categories:

(a) Development Tests

(b) Qualification Tests

(c) Acceptance Tests

4.1.1 Witnessing of Tests. - Grumman and the designated government inspection agency shall be advised one week in advance when tests are to be conducted so that representatives may be present to witness the tests.

4.2 Test Facilities. -

4.2.1 General. - Private, commercial or government test facilities may be used subject to Grumman approval.

4.2.2 Environmental Test Facilities. - The environmental test facilities used in conducting tests shall be capable of producing and maintaining the test conditions outlined in the test plan. These facilities shall be of a size and volume such that the item under test shall not interfere with the generation and maintenance of the required test conditions.

4.2.2.1 Environmental Protection. - Equipment which requires special environmental control, such as hermetic sealing, insulation, vibration isolation, etc., shall be tested with the special environmental control applied.

4.2.3 Standard Conditions. - Tests conducted without utilizing special environmental shall be conducted under the following standard ambient conditions:

(a) Temperature 57° to 97°

(b) Relative Humidity 95% or less

(c) Barometric Pressure Local Atmospheric

4.2.4 Instrumentation Calibration. - All inspection measuring and test equipment shall be calibrated against certified secondary standards which have been calibrated against primary standards by the National Bureau of Standards or an accepted testing organization. The calibration intervals shall be proposed by the vendor and be subject to approval by Grumman. Records shall be maintained indicating the date of last calibration and due date.

4.2.4 (Continued)

The due date shall be displayed on each item of inspection, measuring and test equipment or tools. The procedures and means shall be provided for periodic operational checks on each item of inspection, measuring, and test equipment prior to use. (e.g., warmup and setting of electronic instruments, and check of micrometers against shop standards.)

4.2.4.1 Test Condition Tolerances. - The tolerance on test conditions shall be specified for each test. Acceptable values are:

(1)	Temperature	$\pm$ 3.0°F
(2)	Vibration Amplitude	$\pm$ 10%
(3)	Vibration Frequency	$\pm$ 2%
(4)	Random Vibration	The vibration acceleration density applied to the test shall be within $\pm$ 2db of the specified test level over broad regions of the spectrum between 20 and 1000 cps and $\pm$ 4 db between 1000 and 2000 cps.
(5)	Shock Amplitude	$\pm$ 15%
(6)	Acceleration Amplitude	$\pm$ 5%
(7)	Barometric Pressure	$\pm$ 2%
(8)	Humidity	$\pm$ 5%
(9)	Time	$\pm$ 5%
(10)	Pressure	$\pm$ 5%

4.2.5 Sensing and Recording Equipment. - Sensing and recording equipment of adequate response shall be used to obtain data during transient conditions of the propellant tank tests requiring the evaluation of time versus test data.

4.2.6 Mounting Fixtures. - The mounting fixtures shall support the items under test in a manner that is representative of their location in the LEM System.

4.3 Test Procedures. -

4.3.1 Leakage. -

4.3.1.1 Leak Detection. - The propellant tank shall be tested for leakage at a pressure level of 15 psig and then 270 psig at $70^{o}F \pm 20^{o}F$. The vendor shall propose methods of leak detection for the propellant tank assembly. Any detectable leak shall require that the item be submitted to a leakage rate test. The total leakage rate shall not exceed the equivalent of a 10^{-3} cc/sec. helium leakage rate for the above pressure and temperature as specified in FED-STD-151 method 441 or 442.

4.3.1.2 Vacuum Leakage Rate. - When vacuum leakage rate tests are required, the sealed test specimen shall have a small known amount (10-15% by volume) of helium inserted into it prior to sealing. The test specimen shall be placed in a vacuum chamber capable of attaining pressures in the 10^{-6} mm of Hg. range or lower. The chamber shall be evacuated and a leak check made using a calibrated helium mass spectrometer, and the actual percentage of helium used, shall be noted.

4.3.2 Proof Pressure. - The tank shall be filled with a pressurizing liquid, and the pressure shall be increased to 360 psig in increments of 25 psig. The rate of pressure increase should not be greater than 25 psig per minute. Each incremental level of pressure shall be held for data acquisition and the proof pressure shall be maintained for at least 2 minutes.

4.3.3 Creep. - The tank shall be filled with a pressurizing liquid and mounted in a thermal chamber with provisions for accessibility, visual inspection and drainage. The temperature of the specimen and chamber interior shall be stabilized at 100°F. Then the tank shall be pressurized to 270 psig at a rate not to exceed 25 psig per minute. The temperature and pressure shall be maintained for a continuous period of 6 hours. Data recordings shall be made periodically during the course of the test, and should include but not be limited to temperature, pressure, strain, and circumferential growth all with respect to time.

4.3.4 Cycling Pressure. - The test set-up shall be similar to that used in proof pressure testing with a servo system included in the installation for controlling the pressure cycle. The tank shall be filled with the pressurizing liquid, and the pressure shall be cycled 400 times between 0 psig and 270 psig. The time duration for each complete cycle shall not be less than 30 seconds.

4.3.5 Burst. - The test set-up shall be similar to that used in proof pressure test. The tank shall be filled with a pressurizing liquid, and the pressure shall be increased continuously to a level of 270 psig at a rate not to exceed 25 psig per minute. Pressure shall then be increased to 405 psig in 10 psi increments. Each increment shall be maintained for 30 seconds and the 405 psig level shall be maintained for not less than 2 minutes. Above 405 psig pressure will be increased continuously to burst. Stress, pressure, and circumferential growth shall be recorded at each incremental level between 270 and 405 psig, and continuously above 405 psig to burst.

4.3.6 Shock. - An apparatus shall be used which is capable of providing a sawtooth shock load with a linear rise time of 11 ± 1 milliseconds and with a 1 ± 1 millisecond decay time. The test units shall be mounted empty in accordance with 4.2.6. The measurement of the shock input shall be accomplished at the mounting interface of the test unit. The test shall be conducted under standard conditions of 4.2.3.

4.3.7 Sustained Acceleration. - The test unit shall be mounted on the test apparatus (centrifuge) in such positions to produce the accelerations shown in Table IV at the tank center of gravity and in the directions specified for a particular test. The tank shall then be filled with fluid of .0525 lbs/in.^{3} density and the loads applied without pressure and with 180 psig tank pressure. The test shall be run at standard condition of 4.2.3.

4.3.8 Vibration. - All vibration tests shall be accomplished in the three mutually perpendicular directions parallel to the tank X-X, Y-Y and Z-Z coordinate axes. The tank coordiante axes are defined in Specification Control Drawing LSC280-400. Test units and jig assemblies shall be mounted directly to the shaker head. If this type of mounting is not practicable, slip tables may be utilized. A complete log of each vibration test shall be maintained, including all resonant frequencies, instrumentation used, design changes made, and a detailed account of the performance of the equipment under test. If, in attempting to equalize vibration input or determine fixture resonances, it is necessary to apply vibration energy to test units prior to actual test, the vibration RMS - g value shall be kept to a minimum and shall never exceed 50% of the actual test values. The test levels for tanks empty or full (with a liquid of .0525 lbs/in.^{3} density) pressurized or unpressurized are given in Table IV. The values of the test level shall be taken from Table IV and recorded; however, the force input from the test fixture to the specimen shall not exceed 11,500 lbs. when the tanks are full.

4.3.8.1 Vibration Fixtures. - The fixture connecting the test unit with the shaker head shall be capable of transmitting the vibrations specified herein. Resonant frequencies of fixtures compensated for test unit mass, shall be above 750 cps. The transverse motion (crosstalk) in any direction produced by these fixtures shall not exceed the vibration levels in the transverse direction specified herein. The requirements outlined above shall be verified by a sinusoidal vibration sweep at test frequencies using a mass simulated dummy test item.

4.3.8.2 Sinusoidal Vibration. - The vibration input levels shall be measured at or near each test unit mounted location. Whenever more than four mounting locations exist, only four points need be monitored. Any accelerometer fastened at one of the mounting locations can be used as the servo control input provided that:

(a) The control input maintains levels at the test frequency within ± 1 db of the requirements.

(b) The level at any input location is within ± 4 db of the requirements at the test frequency.

(c) The average of all inputs at the test frequency is within ± 2 db of the requirements.

Exceeding the lower limits of the above tolerances shall be cause for rejection of the delinquent portion of the test and shall necessitate rerunning only that portion of the vibration test. The recording of the accelerometer output signals shall be accomplished on a continuous recording device. The recording device shall have a response capability such that the complete signal wave form may be examined and analyzed. A sinuosidal vibration sweep test at 50% of the required sinusoidal levels shall be conducted to demonstrate compliance with the required control limits.

4.3.8.3 Random Vibration. - The vibration input for this test shall be controlled from the same accelerometer as used to control the sinusoidal vibration test. The spectrum at test levels shall be analyzed and a plot of acceleration spectral density (g^2/cps) versus frequency shall be compiled for each random test. The analyzing filter shall have a maximum band width of 1/3 octave or 100 cps, whichever is less.

4.4 Tests. -

4.4.1 Development Tests. - Development tests shall be conducted to provide data to be used in the design or in the support of the design of the propellant tank assembly. Development tests shall be used to determine stress-to-failure mode and weak link characteristics for verification of analysis and determination of strength margins. Vibration amplification factors shall be substantiated during development testing.

4.4.1 (Continued)

Development tests shall be categorized as follows:

(a) Design Feasibility Tests

(b) Design Verification Tests

4.4.1.1 Design Feasibility Tests. - Design feasibility tests shall include all tests conducted for the following purposes:

(a) Component and part selection.

(b) Selection of weldment process, heat treat process and forging process.

(c) Selection of materials.

(d) Substantiation of safety margins or other analytical assumptions.

4.4.1.1.1 Billets and Forgings. - Billets and forgings shall be in accordance with the applicable portions of 3.2.1.1, 3.2.1.3 and Table II.

4.4.1.1.2 Welding. - Weld process approval for a particular weldment shall be granted after a demonstration has proved that the test rings of 4.4.1.1.3 meet the tensile strength requirements of 3.16.3.2.8. Premature failure of a test ring or component weld, shall require weld process reapproval.

4.4.1.1.3 Test Rings. - The strength, ductility, and the potential effect of weld defects shall be evaluated by circumferentially welding four test rings of the diameter and thickness of the propellant tanks. The welding processing details and procedures shall be identical to those to be employed in the fabrication of the propellant tanks. Each test ring shall be inspected for compliance with welding requirements of paragraph 3.16.3.2 and 4.4.1.1.5. A minimum of six (6) longitudinal and six (6) transverse tensile test specimens as shown in Figure 1, shall be machined from each ring and tested to evaluate the efficiency of the weld. Locations and condition of all tensile test specimens shall be approved prior to machining and testing as per FED-STD-151 method 211. In the event that a welding process change is planned during the

4.4.1.1.3 (Continued)

fabrication of the propellant tanks which may effect the joint efficency, four additional test rings as described above shall be prepared for test.

4.4.1.1.4 The feasibility of producing sound repair welds and multiple repair welds shall be demonstrated by fabricating four additional test rings and testing each ring as follows:

(a) 1st 120 degree segment Single welds

(b) 2nd 120 degree segment repair once.

(c) 3rd 120 degree segment repair twice.

The longitudinal and transverse tensile specimens shall be taken from each segment of each ring. The weldment shall be 100 percent radiographically inspected. The results shall be submitted to Grumman for approval.

4.4.1.1.5 Welding Requirements. -

4.4.1.1.5.1 Imperfect Fusion. - Imperfect fusion is defined as a condition where the weld deposit metal fails to melt together with the base metal or previous weld deposite over the entire surfaces exposed for welding.

4.4.1.1.5.2 Isolated Porosity. - Isolated porosity is defined as a condition existing when the image of a cavity of maximum size specified in Para. 4.4.1.1.5.6 (a) is spaced from another cavity defined as isolated porosity by a distance of at least .150 inches.

4.4.1.1.5.3 Scattered Porosity. - Scattered porosity is defined as a condition existing when there are two or more cavities with diameters specified in Para. 4.4.1.1.5.6 (b) and having a minimum distance of 3 times the major diameters between the cavities. This spacing limit will also apply when scattered porosity is adjacent to isolated porosity.

4.4.1.1.5.4 T-thickness of Weld. - The T-thickness of weld is the thickness of the thinner of the two adjoining edges of material at the weld.

4.4.1.1.5.5 Radiographic Examaination. - Radiographic examination shall be accomplished by normal vision at IX magnification. All positive indications discernible by normal vision shall be identified. Questionable indications discernible by normal vision shall be verified by the utilization of a viewing glass at 3 to 5X magnification and disposition given only to the questionable indications. Acceptance of the area adjacent the questionable indications shall be determined by lX visual evaluation.

4.4.1.1.5.6 Porosity and Non-Metallic Inclusions. -

(a) Isolated Porosity - Isolated porosity shall be acceptable, maximum size range shall be .021 to .025 inches in diameter or 0.35T, whichever is smaller. There shall be no more than four (4) inclusions per linear inch of weld (Ref. Para. 4.4.1.1.5.2).

(b) Scattered Porosity - Scattered porosity shall be acceptable in size up to .020 inches in diameter. There shall be no more than 0.12 inch total diameter of inclusions per linear inch of weld (Ref. Para. 4.4.1.1.5.3).

(c) Combined Porosity - The summation of the pore diameters as per Para. 4.4.1.1.5.6 (a) and (b) whichever is applied shall not exceed .120 inches total diameter per linear inch of weld.

(d) Porosity with Tails - Porosity with tails or sharp-cornered boundaries shall not be acceptable.

(e) Surface Pores - Surface pores larger than .010 inch diameter or depth shall not be acceptable.

(f) Elongated Porosity - Elongated porosity in which the major axis twice exceeds the minor axis is not acceptable.

(g) Non-Metallic Inclusions - Non-metallic inclusions that are spheroidal in shape shall be included with and not in addition to the porosity limits.

4.4.1.1.5.7 Metallic Inclusions. -

(a) Metallic Inclusions - Metallic inclusions that are sharp-cornered shall not be acceptable.

(b) Metallic Inclusions - Metallic inclusions that are spheroidal in shape shall be included with and not in addition to the porosity limits.

4.4.1.1.5.8 General Defects. -

(a) Undercut - Undercut of the weld bead, below the face of the parent metal shall not be acceptable.

(b) Concavity - Concavity of the weld bead, under the face of the parent metal shall not be acceptable.

(c) Cracks - Cracks shall not be acceptable.

(d) Incomplete Penetration - Incomplete penetration is not acceptable.

(e) Imperfect Fusion - Imperfect fusion is not acceptable.

(f) Notches - Notches are not acceptable.

4.4.1.1.6 Heat Treat. - The metalluirigical test samples defined in 4.4.1.1.3 shall be subjected to the same heat treat cycle as the production tank. Tensile specimens may be straightened prior to stress relief.

4.4.1.1.7 Mechanical Properties. - Ultimate strength, yield strength, and elongation, of each tensile specimen shall be determined per FED-STD-151 method 211. The transverse tensile specimens B1 and B2 of Figure 1 shall be examined as follows:

(a) Macroetch-Photographs (2x) shall be taken of the weldment cross-section as etched.

(b) Microhardness testing-Microhardness surveys (Knopp 200-gram indenture or equivalent) shall be conducted on the weldment cross-sections (weld bead through heat affected zone to parent metal).

4.4.1.1.7 (Continued)

(c) Microetch-Photomicrographs (100x) shall be taken of each weldment cross-section.

4.4.1.1.8 Weldment Inspection. - Each weldment shall be visually inspected and 100% radiographically, and fluoresent penetrant inspected after welding, for compliance with 4.4.1.1.5 prior to further processing.

4.4.1.1.8.1 Fluorescent Penetrant Inspection. - All weldments shall be 100% fluorescent penetrant inspected per MIL-I-6866A after final processing and after acceptance tests are completed.

4.4.1.1.9 Heat Treat Test Specimens (Tanks). - Six test specimens shall be machined from equally spaced locations on the trepanned discs or trim rings of each heat treated forging. Three specimens shall be tested to check the acceptability of the forging per Table II. During the stress relief of each tank, three test specimens originating from each hemispherical forging shall be suspended at equally spaced locations around the tank and tested to check the final properties of the tank per 3.6.3.2.8.

4.4.1.1.9.1 Heat Treat Test Specimens (Cover). - Three test specimens shall be machined from each heat from which the covers are forged to certify the material. Three additional specimens from the same heat for each cover shall be utilized to certify the heat treat response. During stress relief, the specimens shall be located adjacent to the component. The tensile tests shall then be performed.

4.4.1.1.9.2 Surface Condition. - After completion of tensile test, the specimens shall be evaluated to determine the extent of oxidation and surface contamination.

4.4.1.1.10 Measurements. - Each tank shall be inspected dimensionally after stress relief for conformance to the requirements of Specification Control Drawings LSC-280-400, 401, 402 and 403.

4.4.1.1.10.1 Wall Thickness. - Wall thickness measurements shall be conducted by Videgage method or equivalent, that shall have an accuracy of 0.002 inch or plus or minus 0.1 percent of the wall thickness, whichever is greater.

4.4.1.2 Design Verification Tests. - Design verification tests are advance stage development tests which shall be performed on the propellant tank for the purpose of substantiating the correctness of the design for its intended mission. Successful completion of design verification tests provide the assurance necessary to permit a design freeze decision to be made. These tests shall include the requirements of paragraph 4.4.1.1 and Table V.

4.4.1.2.1 Reliability Assurance. - As an integral part of the Descent Tank Design Verification test program the Tank Assemblies shall meet the requirements of paragraph 4.3 and Table V. No failure other than that specified in paragraph 4.3.5 shall be permitted during the tests.

Successful completion of these tests shall be a prerequisite to the start of the formal Qualification Test. Tests applicable to reliability assurance shall fulfill the following essentials:

(a) The tests shall be conducted on equipment which is representative in design, physical configuration and material to deliverable flight weight equipment as approved in the Test Plan.

(b) The above items are tested to failure under systematically increasing internal pressure (Burst). Failure is described as rupture or evidence of incipeant failure of any portion of the tank.

A failure mode prediction analysis shall be completed prior to the start of the reliability assurance test. The analysis shall be conducted as specified in the Purchase Order.

4.4.1.2.2 Analysis of Results. - Vendor shall perform an engineering analysis of the data generated by the stress-to-failure tests including a correlation with the Failure Mode Prediction Analyses and submit the data and the analysis to Grumman.

4.4.2 Qualification Tests. - Qualification tests shall be conducted on samples identical to production Propellant Tank Assemblies for the purpose of verifying their conformance with this specification.

4.4.2.1 General. - Prior to any qualification tests, the Propellant Tank Assembly shall undergo acceptance tests in accordance with paragraph 4.4.3. The propellant tank assembly and test apparatus shall be subjected to inspection by Grumman quality control representatives. At convenient times prior to and after the tests, the propellant tank assembly shall be examined to determine conformance to all requirements. At the option of Grumman, measurements shall be made of critical Propellant tank Assembly dimensions prior to start of the qualification tests. During the progress of tests, examinations may be made at the option of Grumman. The results of these examinations shall be a part of the qualification test data. Propellant Tank Assemblies that have undergone qualification tests shall not be used for flight acceptance tests, nor shall they be used as flight equipment or flight spares. All parts or elements which have been subject to qualification tests, either individually or as part of a larger assembly shall be distinctively marked as qualification tested parts. Items of equipment which have been qualification tested, shall not be used for qualification testing as part of a higher order assembly.

4.4.2.1.1 Parts Failure and Replacement. - Maintenance, adjustment, or replacement of parts shall not be permitted during qualification testing except when approved by Grumman.

4.4.2.2. Propellant Tank Assembly Inspection and Tests. -

4.4.2.2.1 Propellant Tank Assembly Inspection Before Tests. - All components shall be completely inspected for compliance with drawings and specifications prior to qualification testing. Deviations from the drawings and specifications shall be cause for rejection unless approved by Grumman. Defective parts shall not be used on any propellant tank assembly subjected to the qualification tests.

4.4.2.2.2 Propellant Tank Assembly Tests. - The Propellant Tank Assembly Tests shall include the requirements of paragraph 4.4.1.1 and Table VI.

4.4.2.2.2.1 Weight. - The Propellant Tank Assembly components shall be weighed and its weight shall not exceed the value specified in 3.19.

4.4.2.2.2.2 Fungus. - Propellant Tank Assembly components shall be subjected to a fungus test as specified in Table IV if these components are fabricated of fungi nutrient materials.

4.4.2.2.3 Propellant Tank Assembly Inspection After Tests. - After completion of tests the propellant tank assembly shall be subjected to a visual examination and measurements taken, as necessary, to disclose excessively worn, diestorted, or weakened parts. Photographs shall be taken of such discrepant parts and these photographs shall be included in the test report.

4.4.2.2.4 Qualification Conditions. - Qualification of the Propellant Tank Assembly shall be predicated on maintenance of all parameters within specified limits.

4.4.3 Acceptance Tests. - Acceptance tests shall be conducted on deliverable items to provide assurance that the Propellant Tank Assembly is within the limits of the design parameters and is free from material, construction, workmanship and functional deficiencies. All Propellant Tank Assemblies delivered for fulfillment of the Purchase Order shall be subjected to an acceptance test.

4.4.3.1 General. - The Propellant Tank Assembly, the test apparatus and the material entering into the manufacture of articles for fulfillment of the Purchase Order, shall be subjected to inspection by authorized Grumman representatives. At convenient times prior to and after the tests, the Propellant Tank Assembly shall be examined to determine conformance with the requirements of the Purchase Order. During the progress of tests, examinations may be made at the discretion of Grumman. Propellant Tank Assembly for use on flight spacecraft shall not have been subjected to more than two (2) acceptance test programs nor have been subjected to environments of an intensity higher than acceptance test levels.

4.4.3.2 Propellant Tank Assembly Inspection and Tests. -

4.4.3.2.1 Propellant Tank Assembly Inspection Before Acceptance Test. - Each Propellant Tank Assembly shall be completely assembled in accordance with the drawings, then visually and dimensionally inspected before commencing the tests.

4.4.3.2.2 Propellant Tank Assembly Tests. - Each Propellant Tank Assembly as assembled for the inspection specified in 4.4.3.2.1 shall be subjected to the tests outlined in paragraphs 4.4.3.2.2.1 through 4.4.3.2.2.7 in the order specified.

4.4.3.2.2.1 Proof Test. - The propellant tank assembly shall be subjected to a proof test using the procedure of 4.3.2.

4.4.3.2.2.2 Leak Test. - The propellant tank assembly shall be subjected to a leak test using the procedure 4.3.1.

4.4.3.2.2.3 Vibration. - The Propellant Tank assembly shall be subjected to random vibration tests using the procedure of 4.3.8 with the conditions of Table VII.

4.4.3.2.2.4 Leak Test. - The propellant tank assembly shall be subjected to leak test using the procedure of 4.3.1.

4.4.3.2.2.5 Weight Test. - The propellant tank assembly shall be subjected to a weight test and its weight shall not exceed the value specified in 3.19.

4.4.3.2.2.6 Rinse Test. - The cleanliness of the Propellant Tank Assembly shall be verified by a rinse test in accordance with LSP-270-0001.

4.4.3.2.2.7 Capacity Verification. - The vendor shall measure the propellant tank volume and the volume shall not be less than that specified in 3.8. Residual fluids shall also be measured and recorded.

5 PREPARATION FOR DELIVERY

5.1 General. - The preparation for delivery shall render the propellant tank assembly capable of long term storage and shipment without degradation of reliability because of corrosion, contamination, physical damage from slosh, vibration or other shipping hazards encountered during handling and transportation to Grumman.

5.1.1 Procedure. - Written procedures shall be submitted to Grumman for packaging in accordance with Section E of the Purchase Order.

5.2 Preservation and Packaging. - The Propellant Tank Assembly shall be packed in such a manner as to meet the environmental requirements stated in Table III of this specification. Cleanliness of the barrier materials shall be equal to or greater than the cleanliness level of the Propellant Tank Assembly.

5.3 Adequacy of Packaging and Packing. - Adequacy of the packaging and packing shall be verified by tests according to Method 516, Procedure III of MIL-STD-810. Tests shall be performed on packaged Propellant Tank Assembly or a dummy load. The Propellant Tank Assembly or dummy load shall be instrumented to determine the maximum acceleration and pulse duration experienced along the three major axes. Location of the accelerometers shall be approved by Grumman. Recorded accelerations during the tests shall not exceed the design shock limit levels.

5.4 Marking of Shipments. - Interior and exterior containers shall be durably and legibly marked. The markings shall provide the following information:

Item Name ____________________

Contractor's Control No. ____________________

Stock No. ____________________

Contractor's Order No. ____________________

Manufacturer ____________________

Mfg.'s Serial No. ____________________

Date of Manufacture ____________________

6 NOTES

6.1 Definitions. - For the purposes of this specification the following definitions shall apply.

Pyrophoric Reaction - A spark or ignition of tank material in the presence of Nitrogen Tetroxide occuring spontaneously or as a result of motion, deformation or impact of tank material.

Effective Surface - Those surfaces of the Propellant Tank Assembly which will come in contact with the stored propellants.

TABLE I

Typical LEM Vehicle Tank Life Cycle

Event	Operating Time (seconds)	Non-Operating Time (hours)	Environmental and load conditions from Table III
Pre-launch (NOTE 1, 2 acceptance test	90	--	--
Pre-launch (ready condition)	--	*up to 180 days	B
Launch, boost	--	.2	C
Space flight to LEM separation	--	87.2	D
Insertion into landing trajectory	30	--	E
Coast	--	2.53	E
Powered Descent	360	--	E
Hover to Landing	120	--	E
Post landing	--	22.98	E

*Ready condition - period between final hot firing acceptance test until fill for launch.

TABLE I (Continued)

NOTE 1: Cold flow testing will be performed at Grumman. Hot firing involving flow from tanks will be conducted at AMR. Between these tests the propellant tanks shall be subjected to transportation transients enroute.

NOTE 2: Propellant tanks will be subjected to not less than 40 fill, pressure, flow, drain, flush and purge cycles during the ground test and pre-launch programs. During these periods the tanks may be continuously exposed to propellants for periods up to 1 month and may have intermittant exposure over a period of 18 months.

TABLE II

QUALITY ASSURANCE TESTS FOR

FORGINGS AND FORGING MATERIALS

Type of Tests	Billets		Forgings
Chemical Analysis			
General Chemistry	Mid-radii Top or Bottom	100%	100%
Residuals Gas Analysis	Top or Bottom	100%	100%
MACRO Examinations			
Chemical Segregations	Top & Bottom Macroslabs	100%	N (a)
Grain Flow	N		1st piece
MICRO Examinations			
Surface Oxidation	N		N (g)
Beta Transus Determination	Mid-radii Top & Bottom	(b) 100%	S S
General Structure Grain Size Determination	Top & Bottom	S	(c)
Heat Treat Response Tensile Tests (a) & (d) 0.252 inch diameter bar to include ultimate tensile strength, yield strength (0.2% offset), reduction of area, and elongation	N		100%
Radiographic Inspection (e)	N		100%
Ultrasonic Inspection (f)	100%		N

TABLE II (Continued)

NOTES: N - Not required or not applicable.

S - Sampling Plan

(a) After the forging technique has been established for each type component, one forging shall be destructively tested to determine the grain flow and mechanical properties. If the forging practice is altered, in each case, one additional forging shall be destructively tested.

(b) Forging temperature shall be below the beta transus temperature of the heat of titanium material being forged. The microstructure shall be equiaxed alpha-beta or plate-like alpha in a beta matrix. Acicular alpha or alpha outlining prior beta grains shall be evidence of overheating and cause for rejection.

Alternate Method: Beta transus determination by the gradiant bar (macro) method permissible. If this method is used, the sample may be taken from top or bottom of billet.

(c) Forging temperatures and reductions shall be controlled to produce as small grain sizes as practical.

(d) Test specimens shall be processed in accordance with the heat treatment per paragraph 4.4.1.1.9 and shall meet the requirements of 3.16.3.2.8.

(e) Radiograph inspection per MIL-STD-453 for conformance to paragraph 3.2.1.1 and 3.2.1.3.1. High density particles or voids are not acceptable in the finish machined component.

TABLE II (Continued)

(f) Ultrasonic inspection to Class A requirements for conformance to paragraph 3.2.1.1 and 3.2.1.3.1; i.e., 5/64 inch maximum indication with 3/64 inch maximum indication on one inch centers. Finish machined components shall have no ultrasonic indications.

(g) Not required provided a minimum of 0.03" is machined from the surfaces of the heat treated and rough machined forgings.

TABLE III

ENVIRONMENTAL AND LOAD CONDITIONS

NOTES:

1. Factors of safety are not included in the levels specified herein. Factors of safety shall be applied to these values and self-generated structural loads of each subsystem.

2. All accelerations are "earth g's". Multiply by earth weight or use 32.2 ft/sec^2 as appropriate.

3. Vibration spectra herein refer to straight lines on a log-log plot.

4. "Packaged" means ready for shipment in the special shipping and storage container.

A. Pre-Launch Packaged (Tanks Empty)

Acceleration:	(ns)	2.67 g vertical with 1.0 g lateral applied to container.
Shock:	(ns)	Transportation, handling and storage in the shipping container shall not produce critical design loads on the propellant tank assembly and shall not effect an increase in weight. Shock as in MIL-STD-810 (USAF) 14 June 1962 Method 516 Procedure III.
Vibration:	(ns)	The following vibration levels are specified during transportation, handling and storage. Vibration to be applied, along three, mutually perpendicular axes, x, y, and z to the container. (In accordance with Table IV.)

TABLE III (Continued)

A. Pre-Launch Packaged (Tanks Empty) (Continued)

Vibration: (Cont.)

	For 100 lb. or less		For 300 lb. or more	
	cps	g or D.A.	cps	g or D.A.
	5-7.2	.5 in D.A.	5-7.2	.5 in D.A.
	7.2-26	± 1.3g	7.2-26	± 1.3g
	26-52	.036 D.A.	26-52	.036 D.A.
	52-500	± 5.0g		
		(f)		(f)

(f) For 100 to 300 lb. use figure 514-8 Method 514 MIL-STD-810 (USAF), 14 June 1962 for maximum frequency.

*Pressure: Atmospheric pressure corresponding from sea level to 50,000 ft.

Temperature: $-65^{\circ}F$ to $+160^{\circ}F$

*Humidity: 0 to 100 percent relative humidity including condensation.

*Rain: Rain as defined in Method 506 MIL-STD-810(USAF) 14 June 1962.

*Salt Fog: Salt fog as encountered in a beach area (equivalent of spray of 5% salt solution in water for 50 hours).

(ns) These levels of Environments and Loads do not occur simultaneously.

* Ambient Environment on outside of package.

TABLE III (Continued)

A. Pre-Launch (Tanks Empty) (Continued)

*Sand and Dust:		As in desert and ocean/beach areas, equivalent to 140 mesh silica flour with particle velocity up to 500 ft/min.
Fungus:		In accordance with Method 508, MIL-STD-810 (USAF) 14 June 1962.
*Ozone:		Exposure with 0.05 parts/million concentration (1/2 toxic limit)

B. Pre-Launch Unpackaged (Tanks Empty)

Acceleration:	(ns)	2.67 Vertical (x-axis) with 1.0 g Lateral (x-y plane)
Shock:	(ns)	Shock as in MIL-STD-810 (USAF), 14 June 1962, Method 516 Procedure I, Modified. Modity shockpulse to saw tooth 15g peak 10-12 ms rise, 0-2 ms decay.
Vibration:	(ns)	Same as pre-launch packaged but applied to equipment.
*Pressure:		Tank Gage Pressure: to vary from ambient to proof gage pressure.
Temperature:		$-20^{o}F$ to $110^{o}F$ Ambient Air Temperature plus 360 BTU/FT^2 HR up to 6 hr/day.
Humidity:		15% to 100% relative humidity including condensation.

*Ambient environment on outside of Package.

(ns) These levels of environments and loads do not occur simultaneously.

TABLE III (Continued)

B. Pre-Launch Unpackaged (Tanks Empty) (Continued)

Rain:	Same as packaged but no direct impingement.
Salt Fog:	As in MIL-STD-810 (USAF) Method 509.
Sand and Dust:	Same as Pre-Launch Packaged.
Fungus:	Same as Pre-Launch Packaged.
Ozone:	Same as Pre-Launch Packaged.

C. Launch and Boost (Tanks Full)

Accelerations and Tank Pressures: (ns)

Loading \ Condition		Boost		Burnout		Engine Hardover	
External Pressure:		Ambient at Sea Level to 1 x 10^{-10} mm Hg.					
Internal Pressure		15.	120	15.	120	15.	120
Nx	See	4.70	4.70	-2.6	-2.6	2.3	2.3
Ny	Tank Assy.	±0.1	±0.1	±0.1	±0.1	±.445	±.445
Nz	Drawing LSC280-400	±0.1	±0.1	±0.1	±0.1	±0.445	±0.445

(ns) These levels of environments and loads do not occur simultaneously.

TABLE III (Continued)

C. Launch and Boost (Tanks Full) (Continued)

External Pressure: (p)	Ambient at sea level to 1×10^{-10} mm Hg
Internal Tank Pressure: (p)	15 to 120 psia.
Vibration: (ns)	The mission environment consists of the following random spectrum applied for 17 minutes along each of the three mutually perpendicular axes, x, y and z. 5-25 cps .18g^2/cps constant 25-34 cps 12 db/Octave roll-off to 34-2000 cps .043g^2/cps constant
Temperature:	+40 to +100°F within the propulsion compartment. 0 to +110°F ambient at sea level.
Humidity:	Same as prelaunch packaged.
Hazardous Gases:	Explosive-proofing requirement defined in Method 511, MIL-STD-810, 14 June 1962.
Radiation:	See paragraph 3.5.1

(p) Pressure act simultaneously with random vibrations.

(ns) These levels of environments and loads do not occur simultaneously.

TABLE III (Continued)

D. Space Flight - Translunar (Tanks Full)

Internal Pressure:	15 to 120 psia
External Pressure:	1 x 10^{-14} mm Hg uncontrolled vacuum
Temperature:	+40° to 100°F in propulsion comp.
Radiation:	Van Allen, Solar Flare & Space background. To be defined as needed (inner belt 10 min. 1/2 hr. delay - outer belt. See paragraph 3.5.1)
Vibration:	The mission environment consists of the following random spectrum applied for 6 minutes along each of the three mutually perpendicular axes, x, y and z.

5-47 cps	.89g^2/cps constant
47-65 cps	12 db/Octave roll-off to
65-1000 cps	.024g^2/cps constant
1000-2000 cps	12 db/Octave rolloff

TABLE III (Continued)

E. Lunar Descent (Tanks Full or Empty)

Vibration: The mission environment consists of the following random spectrum applied for 11-1/2 minutes along each of the mutually perpendicular axes, x, y and z.

10-28	cps	$.18g^2$/cps constant
28-37	cps	12 db/Octave rolloff to
37-1000	cps	$.059g^2$/cps constant
1000-1200	cps	12 db/Octave rolloff to
1200-2000	cps	$.031g^2$/cps constant

External Pressure: 1×10^{-10} mm Hg uncontrolled vacuum

Internal Pressure: 15 to 270 psia

Temperature: 40°F to 100°F propulsion compartment

Radiation: See Paragraph 3.5.1

F. Additional Loading Conditions (Tank Full)

Loading / Condition		I		II		III		IV
Internal Tank Pressure (psia)		15	270	15	270	15	270	270
Nx	See Tank Assy Drawing LSC280-400	±1.6	±1.6	0	0	0	0	0
Ny		0	0	±1.6	±1.6	0	0	0
Nz		0	0	0		+1.6	+1.6	0

External Pressure: 1×10^{-10} mm Hg Uncontrolled Vacuum.

TABLE III (Continued)

G. Design conditions for lateral restraint hardpoint at the +X axis end of the propellant tank assembly.

Condition A: During earth launch a limit lateral load of 4000 lbs. (acting in the Y-Z plane at the +X axis end of the tank) shall be considered in combination with a +4.70g limit axial load factor along the X axis. The lateral load and resultant tank inertia force shall be balanced at the tank-support interface plane. The tank shall be considered full of propellant. The internal ullage volume pressure will vary between 15 psi and 120 psi. The external pressure will vary between ambient at sea level to 1 x 10^{-10} mm Hg uncontrolled vacuum.

Condition B: During lunar landing a limit lateral load of 3000 lbs. shall be considered acting in the Y-Z plane at the +X axis end of the tank. This loading shall be balanced at the tank-support skirt interface plane. The internal tank pressure can vary from zero to 270 psi. The external pressure equals 1 x 10^{-10} mm Hg uncontrolled vacuum.

TABLE IV

REQUIREMENTS FOR QUALIFICATION TESTS

PROPELLANT TANK ASSEMBLY

Test Description	Intensity or Rate	Cycles or Time	Remarks
(1) Pre-Launch			
(a) Vibration Sinusoidal			Test items in packaging container
	0.5 in. D.A. ± 1.30g 0.036 in. D.A. ± 5.0g Use Fig. 514-8 Method 514 MIL-STD-810 (USAF) dated 14 June 1962 for max. cps.	5 - 7.2 cps 7.2 - 26 cps 26 - 52 cps 52 - 500 cps	Vibration shall be applied to the package along three mutually perpendicular axes. The frequency shall be swept at $\frac{1}{2}$ octave per minute. Sweep from min. to max. to min. frequency 3 times.
(b) Shock	15g	11 ± 1 millisec. Rise Time 1 ± 1 Millisec. Decay	Shock shall be applied three times in both directions along three mutually perpendicular axes for a total of 18 shocks. Tank unpackaged and empty.

TABLE IV (Continued)

Test Description	Intensity or Rate	Cycles or Time	Remarks
(2) Launch & Boost			
(a) Vibration			Random vibration shall be 5 minutes for each mutually perpendicular axes for a total time of 15 minutes.
Random:	$.097g^2/cps$	20-2000 cps	
Sinusoidal	.23 in. D.A. 2,875g .0092 in. D.A. 6.90g .0008 in. D.A. 13.8g	5 - 16 cps 16 - 78 cps 78 - 120 cps 120 - 420 cps 420 - 600 cps 600 - 2000 cps	Sinusoidal vibration frequency shall be swept logarithmically from 5 cps to 2000 cps cps and back to 5 cps at 2 octave per minute for one cycle for each orthogonal axis.
Pressure:	180 psig		Tank full.
(b) Acceleration Cond. Boost Burnout Engine Hardover	X Y Z +7.05 $\pm$.15 $\pm$.15 -3.90 $\pm$.15 $\pm$.15 +3.45 $\pm$.668 $\pm$.668	Exposure for 5 minutes per direction for a total of 15 minutes	Accelerations for engine hardover condition shall be combined.
	Pressure: Ambient and 180 psig		Tank full.

TABLE IV (Continued)

Test Description	Intensity or Rate	Cycles or Time	Remarks
(3) Space Flight			
(a) Vibration			
Random	12 db/Octave rise to $.053g^2$/cps 12 db/Octave rolloff	50 - 100 cps 100 - 1000 cps 1000-2000 cps	Random vibration shall be 5 minutes for each of the three mutually perpendicular axes for a total time of 15 minutes.
Sinusoidal	.23 in. D.A. 2.875g .0014 D.A. 8.0g	5 - 16 cps 16 - 200 cps 200 - 330 cps 330 -2000 cps	Sinusoidal vibration frequency shall be swept logarithmically from 5 cps to 2000 cps and back to 5 cps at 2 Octave per minute for one cycle for each orthogonal axis.
	Pressure: 180 psig		Tank full
(4) Lunar Descent			
(a) Vibration			
Random	$.069g^2$/cps 12 db/Octave rise to .133 g^2/cps 12 db/Octave rolloff to $.069g^2$/cps	20 - 85 cps 85 - 100 cps 100 - 1000 cps 1000- 1200 cps 1200- 2000 cps	Random vibration shall be 5 minutes for each of the three mutually perpendicular axes for a total time of 15 minutes.

TABLE IV (Continued)

Test Description	Intensity or Rate	Cycles or Time	Remarks
(4)(a) (Continued)			
Sinusoidal	23 in. D.A.	5 - 16 cps	Sinusoidal vibration frequency shall be swept logarithmically from 5 cps to 2000 cps and back to 5 cps at 2 Octave per minute for one cycle for each orthogonal axis.
	2.875g	16 - 90 cps	
	.0069 in. D.A.	90 - 140 cps	
	6.9g	140 - 350 cps	
	.00103 in. D.A.	350 - 500 cps	
	12.7g	500 - 2000 cps	
	Pressure: 270 psig		This test shall be repeated twice; first with the tank empty and then full."

TABLE V

DESIGN VERIFICATION TESTS

Sequence	1	2	3	4	5	6	7	8	9	10	11	12	13
Test	Proof Paragraph 4.3.2	Leak 4.3.1	Creep Paragraph 4.3.3	Leak	Shock Paragraph 4.3.6 & Table IV	Leak	Vibration Paragraph 4.3.8 & Table IV	Leak	Acceleration Paragraph 4.3.7 & Table IV	Leak	Cycle Paragraph 4.3.4	Leak	Burst Paragraph 4.3.5
Tank 1	X	X	X	X	X	X	XF	X	X	X	X	X	XF
2	X	X	X	X	X	X	X	X	X	X	X	X	XF
3	X	X	X	X	X	X	X	X	X	X	X	X	XF
4	X	X	X	X	X	X	X	X	X	X	X	X	XF
5	X	X	X	X	X	X	X	X	X	X	X	X	XF

Notes: For Tank #1, acceleration and cycle tests shall be performed prior to the vibration test. The vibration test of Tank #1, shall be conducted by applying the vibration condition given in Table IV, Test 4 (a) except that the tabulated ultimate random vibration acceleration density (g^2/cps) values shall be divided by a factor of 1.33 and the tabulated ultimate sinusoidal vibration acceleration and/or double amplitude values shall be divied by a factor of 1.15. A unit test for one axis shall consist of 40 minutes of random vibration followed by 2 sweep cycles of sinusoidal vibration (swept logarithmically at 3/4 Octave per minute from 5 cps to 2000 cps and then from 2000 cps to 5 cps). The total exposure time shall consist of one unit test with the tank empty and pressurized to 270 psi and one unit test with the tank full and pressurized to 270 psi for each of the three mutually perpendicular X, Y and Z axes. If no failureis obtained during the vibration test, Tank #1 shall be failed by burst test.

X Denotes tests to be performed.

TABLE VI

QUALIFICATION TESTS

Sequence	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Test	Weight 4.4.2.2.2.1	Proof Paragraph 4.3.2	Leak 4.3.1	Creep Paragraph 4.3.3	Leak	Shock Paragraph 4.3.6 & Table IV	Leak	Vibration Paragraph 4.3.8 & Table IV	Leak	Acceleration Paragraph 4.3.7 & Table IV	Leak	Cycle Paragraph 4.3.4	Leak	Burst Paragraph 4.3.5
Tank 1	X	X	X	X	X	X	X	X	X	X	X	X	X	X

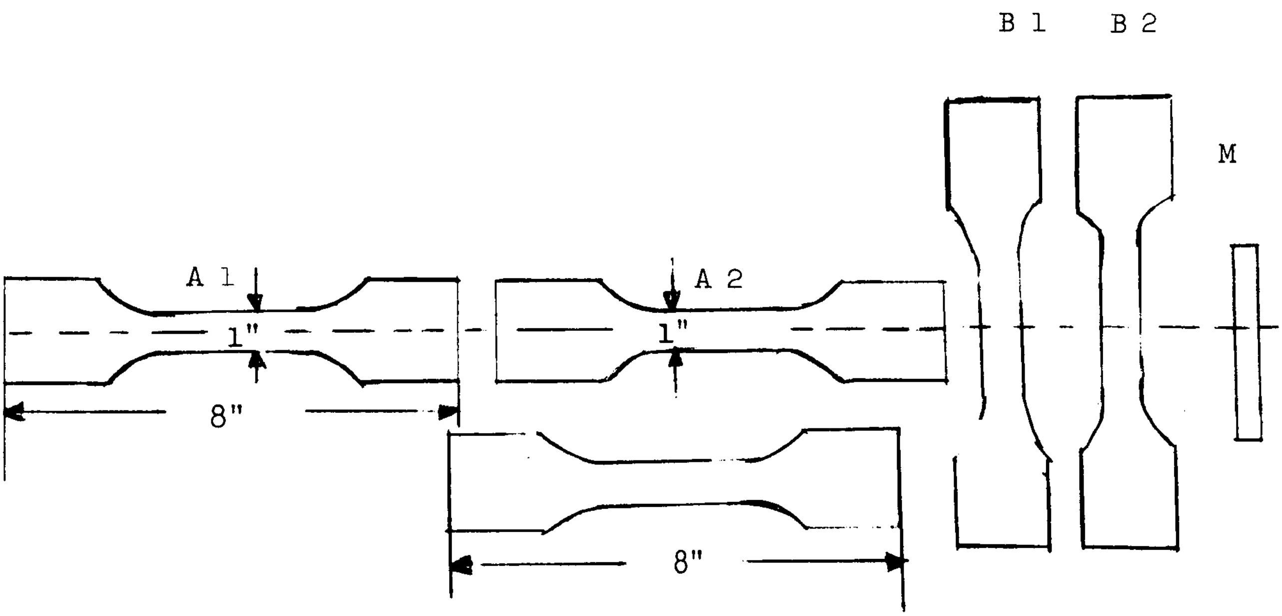
Note: Failure condition will be selected by Grumman at a later date.

X - Denotes Test To Be Performed

TABLE VII

REQUIREMENTS FOR ACCEPTANCE TEST

TEST DESCRIPTION	INTENSITY OR RATE	CYCLES OR TIME	REMARKS
Vibration			
Random	Linear Increase From .02 g^2/cps .07 g^2/cps	15 - 100 cps	Random Vibration shall be 2 minutes for each of the mutually Perpendicular Axes for a total time of 6 minutes.
	Constant .07 g^2/cps	100 - 550 cps	
	Linear Decrease From .07 g^2/cps to 05 g^2/cps	550 - 2000 cps	
	Pressure 270 psi		Tank empty



DENOTATION:

A - Longitudinal Weld
B - Transverse Weld
C - Parent Metal
M - Microscopic Specimen

Typical

FIGURE 1

WELDMENT TESTBAND COUPON WITH METALLURGICAL TEST SPECIMENS

BAFFLE IDENTIFICATION, WIDTHS AND LOCATION

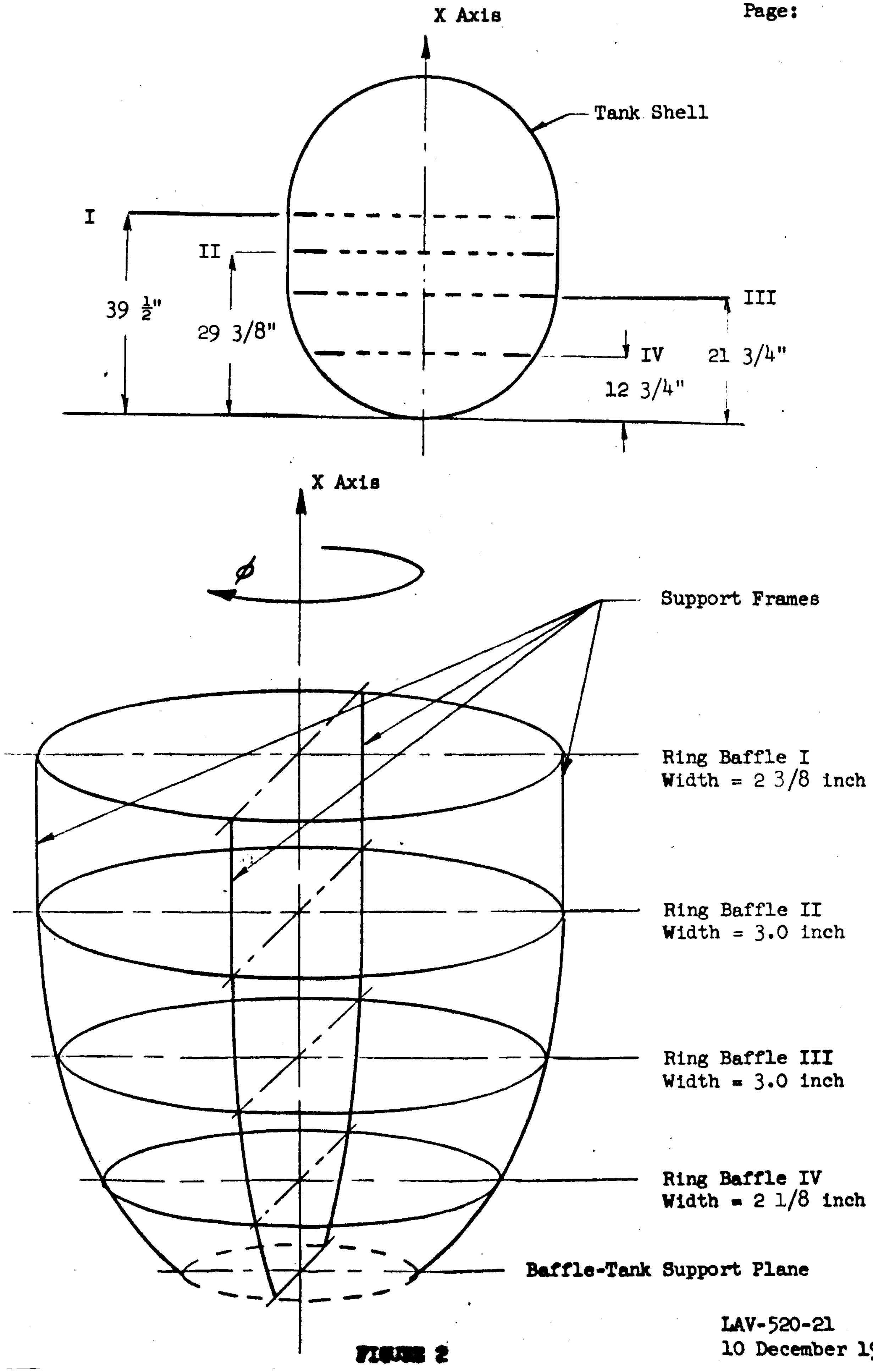
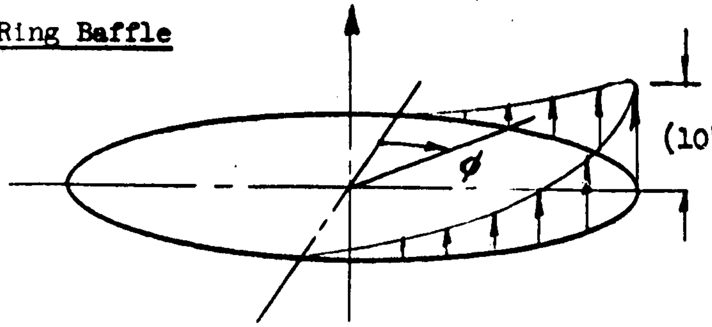


FIGURE 2

BAFFLE LIMIT LOADING INTENSITY AND DISTRIBUTION

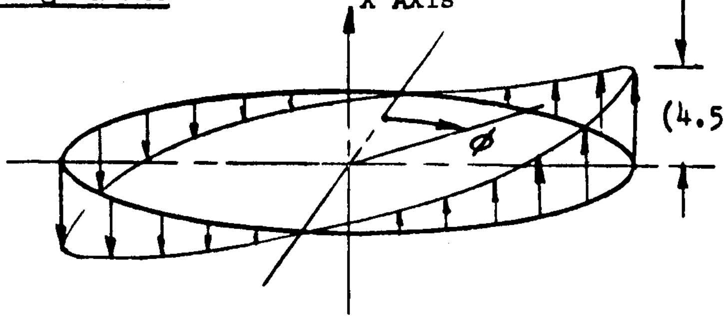
Loading Case 1. Ring Baffle

$0 \leq \phi \leq \pi$

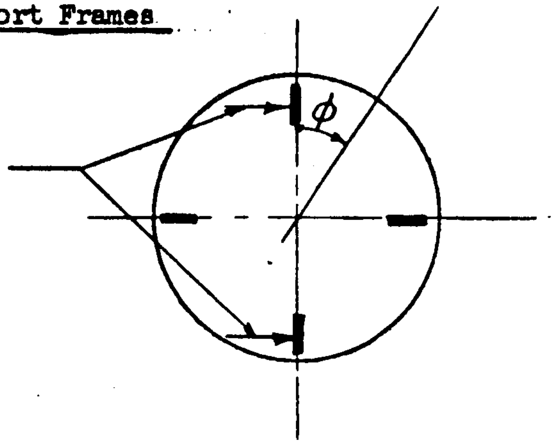


Loading Case 2. Ring Baffle

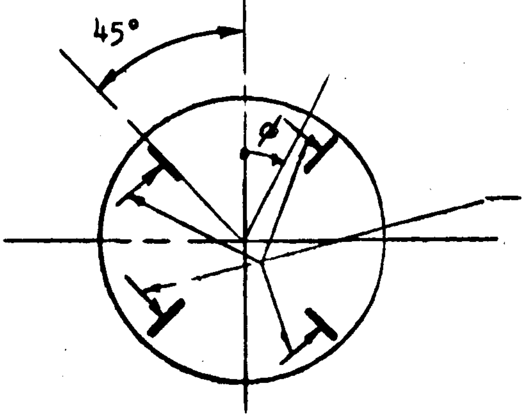
$0 \leq \phi \leq 2\pi$



Loading Case 3. Support Frames



Loading Case 4. Support Frames

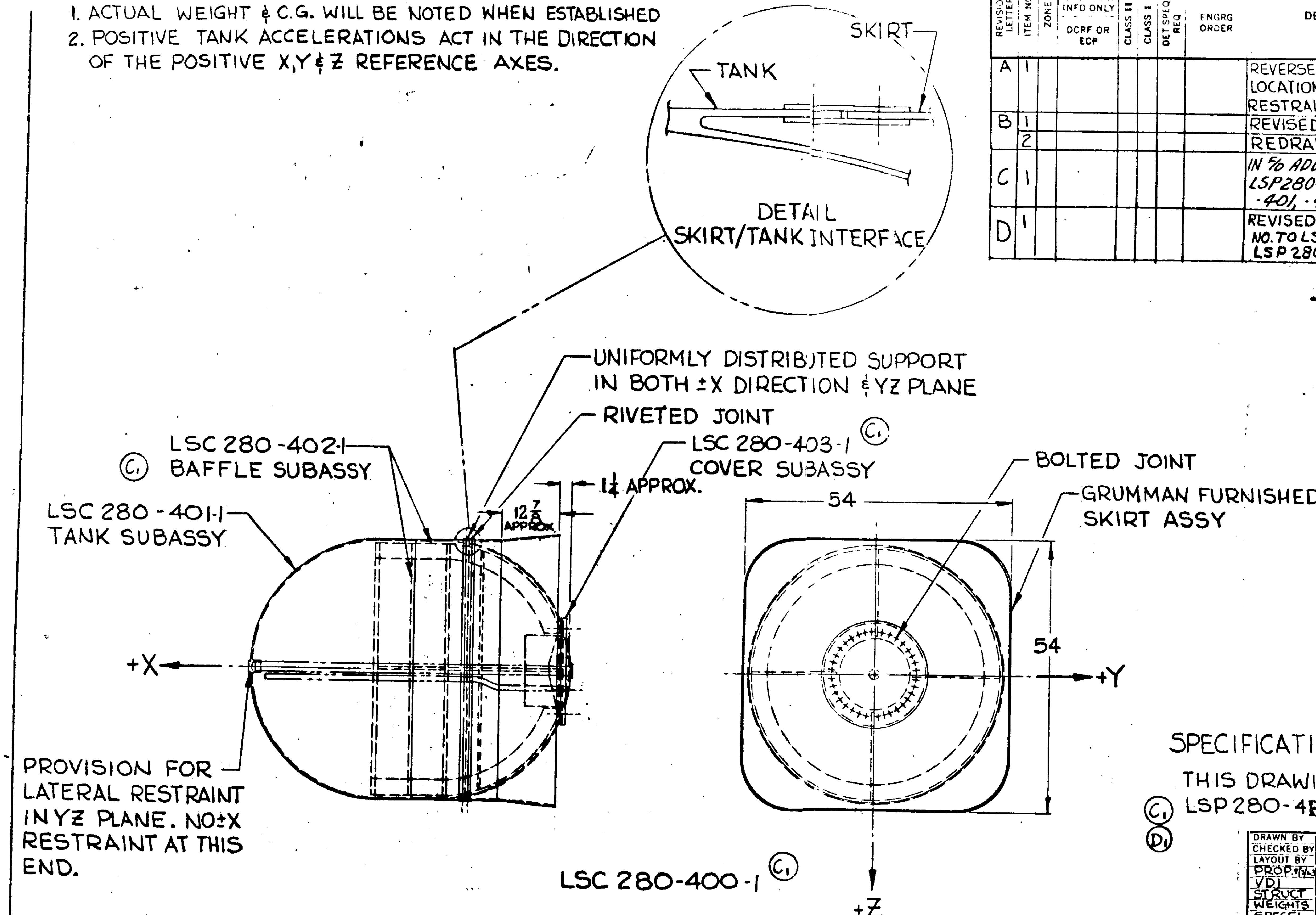


NOTES:

1. ACTUAL WEIGHT & C.G. WILL BE NOTED WHEN ESTABLISHED
2. POSITIVE TANK ACCELERATIONS ACT IN THE DIRECTION OF THE POSITIVE X, Y & Z REFERENCE AXES.

REVISIONS

REVISION LETTER	ITEM NO	ZONE	AUTHORITY FOR REVISION: GRUMMAN INFO ONLY DCRF OR ECP	CLASS II	CLASS I	DET SPEQ REQ	ENGRG ORDER	DESCRIPTION	REVISED BY AND DATE	EFFECTIVE ON MODULE NUMBER	DISPOSITION OF EXIST PARTS: RE-WORK	SCRAP	ENGRG APPD	GOVT APPD
A	1							REVERSED SKIRT ATTACH. LOCATION & LATERAL RESTRAINT PROVISION	TRAUT 11-6-63				[illegible]	
B	1							REVISED SKIRT	W.T. 11-21-63				[illegible]	
	2							REDRAWN						
C	1							IN % ADDED -1 AFTER LSP280-4A, LSC280-400 -401, -402, & -403.	E. STAHL 12-13-63				[illegible]	
D	1							REVISED CONTROL SPEC NO. TO LSP 280-4B WAS LSP 280-4A-1	F. WILSON 7-2-64				RB [illegible]	



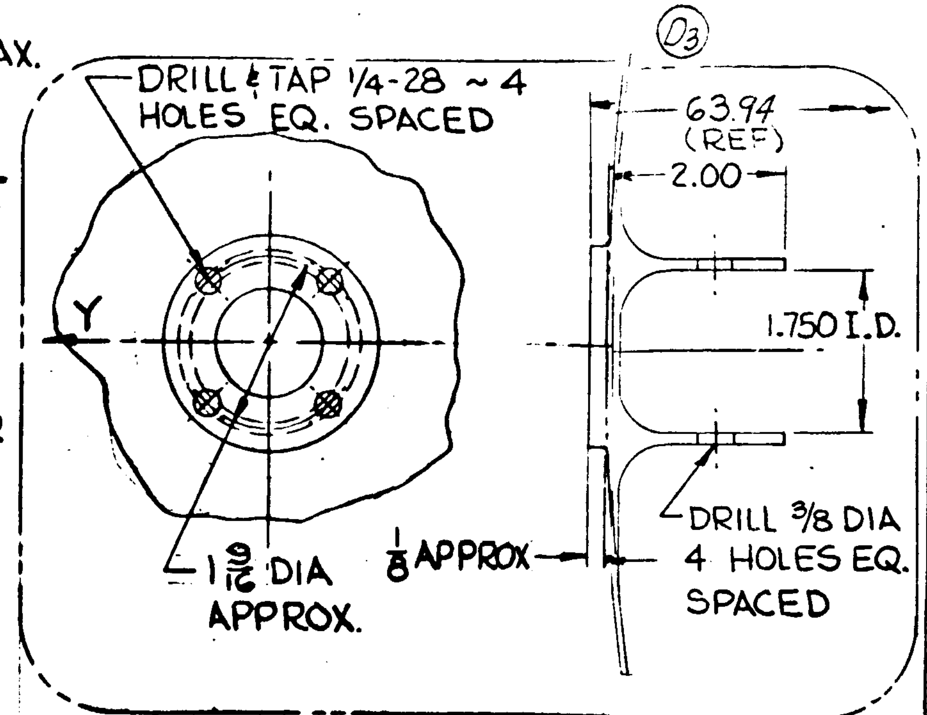
SPECIFICATION CONTROL DRAWING

THIS DRAWING FORMS A PART OF LSP 280-4B CONTROL SPECIFICATION

DRAWN BY	TRAUT	GRUMMAN AIRCRAFT ENGRG CORP, BETHPAGE, L.I., N.Y.	
CHECKED BY	J. PUSATERI		
LAYOUT BY	—		
PROP.	DANNENHOFFER	PROPELLANT TANK ASSY DESCENT STAGE	
VDI	PAULSRUD		
STRUCT	HILDERMAN		
WEIGHTS	ANGELORO		
SPECFI	BERNSTEIN	CONTRACT NO. NAS 9-1100	
SYS COORD	GARDNER		
SUB SYS PROJ	R.H. CARBEE	CODE IDENT NO. 26512	SIZE B · LSC 280-400 D
		SCALE	WEIGHT · SHEET

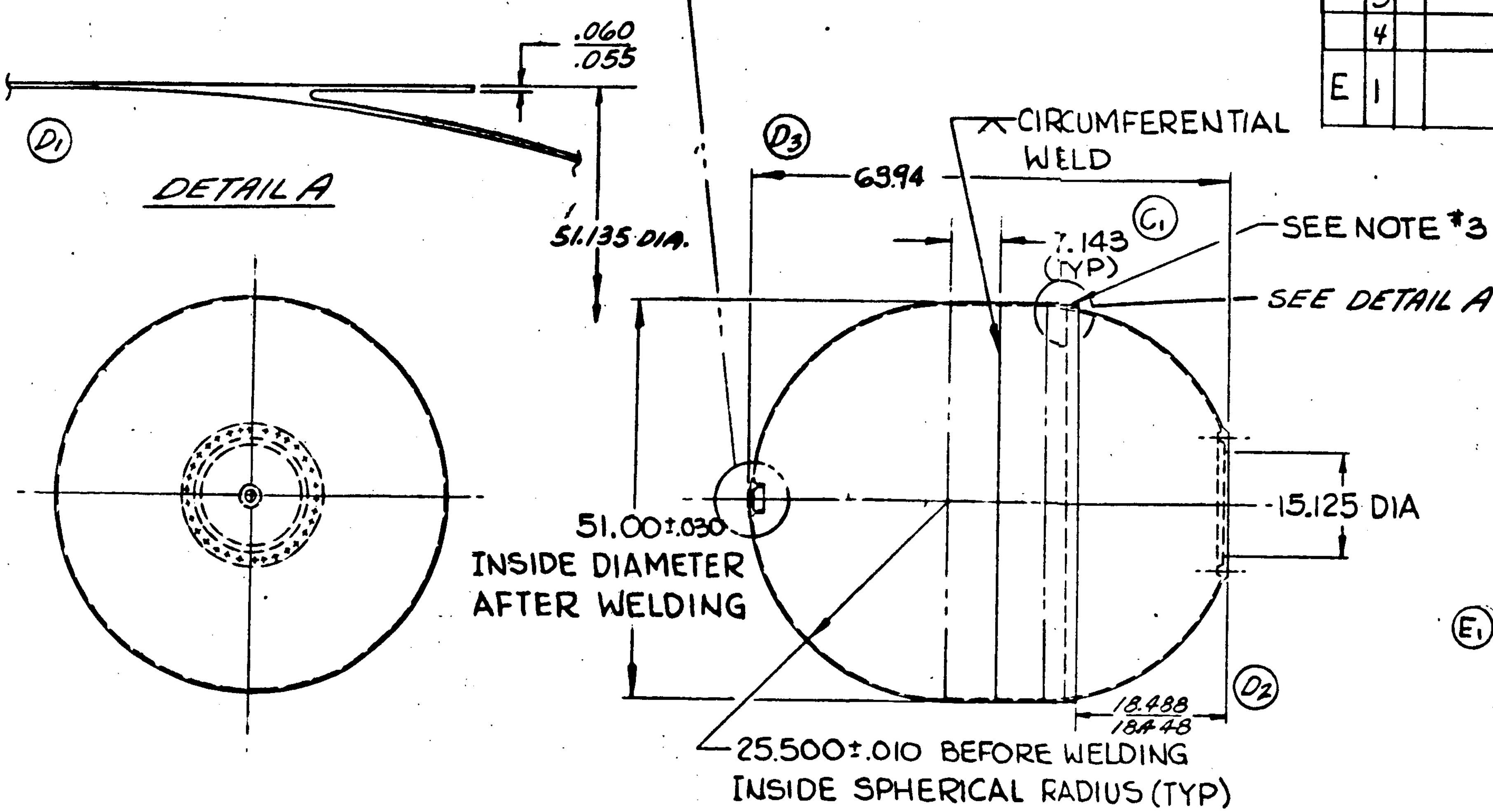
NOTES:

1. TOLERANCE ON THICKNESS TO BE $^{+.005}_{-.000}$ MAX.
2. INNER & OUTER SURFACE ROUGHNESS SHALL BE 63 RMS MAX.
3. TOLERANCE ON TANK DIAMETER AT SKIRT INTERFACE ±.010
4. T.I.R. OF CYLINDRICAL PORTION AFTER WELDING & STRESS RELIEF SHALL NOT EXCEED .300.
5. RATE OF CHANGE OF TANK CONTOUR SHALL NOT EXCEED .010 INCH/INCH FROM THE NOMINAL.



REVISIONS

REVISION LETTER	ITEM NO	ZONE	AUTHORITY FOR REVISION: GRUMMAN INFO ONLY – DCRF OR ECP	CLASS II	CLASS I	DET SPEQ REQ	ENGRG ORDER	DESCRIPTION	REVISED BY AND DATE	EFFECTIVE ON MODULE NUMBER	DISPOSITION OF EXIST PARTS: RE-WORK	SCRAP	ENGRG APPD	GOVT APPD
A	1							REVISED END SUPPORT DETAIL	F.W. 11-6-63					
B	1							ADDED NOTES 3,4 & 5	W. TRAUT 11-21-63					
	2							ADDED TANK TOL. FOR BEFORE & AFTER WELDING						
	3							REVISED TANK LENGTH						
	4							REVISED END SUPPORT DETAIL						
	5							REDRAWN						
C	1							REVISED TANK & CYLINDRICAL SECTION LENGTH	W.TRAUT 12-12-63					
	2							IN F/D ADDED -1 AFTER LSC 280-401 & LSP280-4A	E.S. 12-13-63					
D	1							ADDED DETAIL A	E. STANL 3-9-64					
	2							ADDED DIM $\frac{18.488}{18.448}$						
	3							DIM 63.94 (WAS 63.84)						
	4							LSP-280-4A-4 WAS LSP-280-4A-1					RB	
E	1							REVISED CONTROL SPEC NO. TO LSP280-4B WAS LSP280-4A-4	F. WILSON 7-2-64					



LSC 280-401-1 C2

SPECIFICATION CONTROL DRAWING

E1 D4 C2 THIS DRAWING FORMS A PART OF LSP 280-4B CONTROL SPECIFICATION

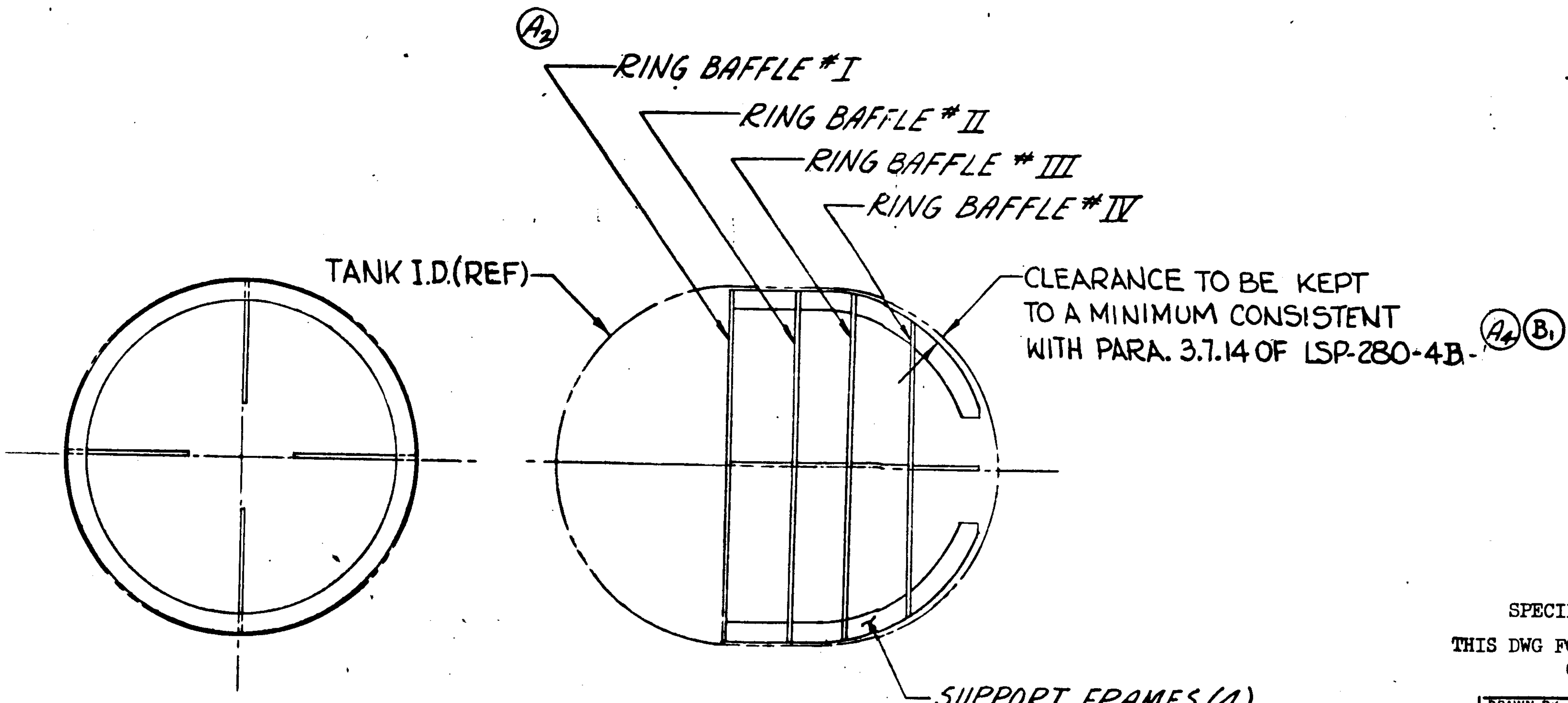
DRAWN BY	WILSON	GRUMMAN AIRCRAFT ENGRG CORP, BETHPAGE, L.I., N.Y.	C
CHECKED BY	J. PUSATERI	TANK SUB-ASSEMBLY	
LAYOUT BY	—		
PROP 5/17/63	DANNENHOFFER		
VDI	PAULSRUD		
STRUCT	HILDERMAN		
WEIGHTS	ANGELORO	CONTRACT NO. NAS 9-1100	
SPECFI	BERNSTEIN		
SYS COORD	GARDNER	CODE IDENT NO. 26512 / SIZE B / LSC 280-401	E
SUB SYS PROJ	R.M. CARBEE	SCALE / WEIGHT / SHEET	

NOTES:

1. Method of attachment to be determined by Vendor subject to Grumman approval.

REVISIONS

REVISION LETTER	ITEM NO	ZONE	AUTHORITY FOR REVISION: GRUMMAN INFO ONLY — DCRF OR ECP	CLASS II	CLASS I	DET SPEQ REQ	ENGRG ORDER	DESCRIPTION	REVISED BY AND DATE	EFFECTIVE ON MODULE NUMBER	DISPOSITION OF EXIST PARTS: REWORK	SCRAP	ENGRG APPD	GOVT APPD
A	1							DWG TITLE, BAFFLE SUBASSY (WAS BAFFLE CONFIGURATION	E. STAHL 12-13-63					
	2							REVISED BAFFLE ASSY						
	3							IN F/D ADDED -1 TO LSC 280-4A & LSC 280-402						
	4							IN F/D CLEARANCE NOTE, ADDED "A" TO LSP 280-4						
B	1							LSP-280-4B WAS -4A-1 (2 PLACES)						



LSC-280-402-1 (A3)

SPECIFICATION CONTROL DRAWING (B1)

THIS DWG FORMS A PART OF LSP-280-4B CONTROL SPECIFICATION (A1) (A3)

DRAWN BY		GRUMMAN AIRCRAFT ENGRG CORP BETHPAGE, L.I., N.Y.
CHECKED BY		BAFFLE SUBASSEMBLY
LAYOUT BY		
PROP		
VDI		
STRUCT.		CONTRACT NO. NAS 9-1100
WEIGHTS		
SPECF		CODE IDENT NO. 26512 — SIZE B — LSC-280-402 B
SYS COORD		
SUBSYS PRG		SCALE — WEIGHT — SHEET

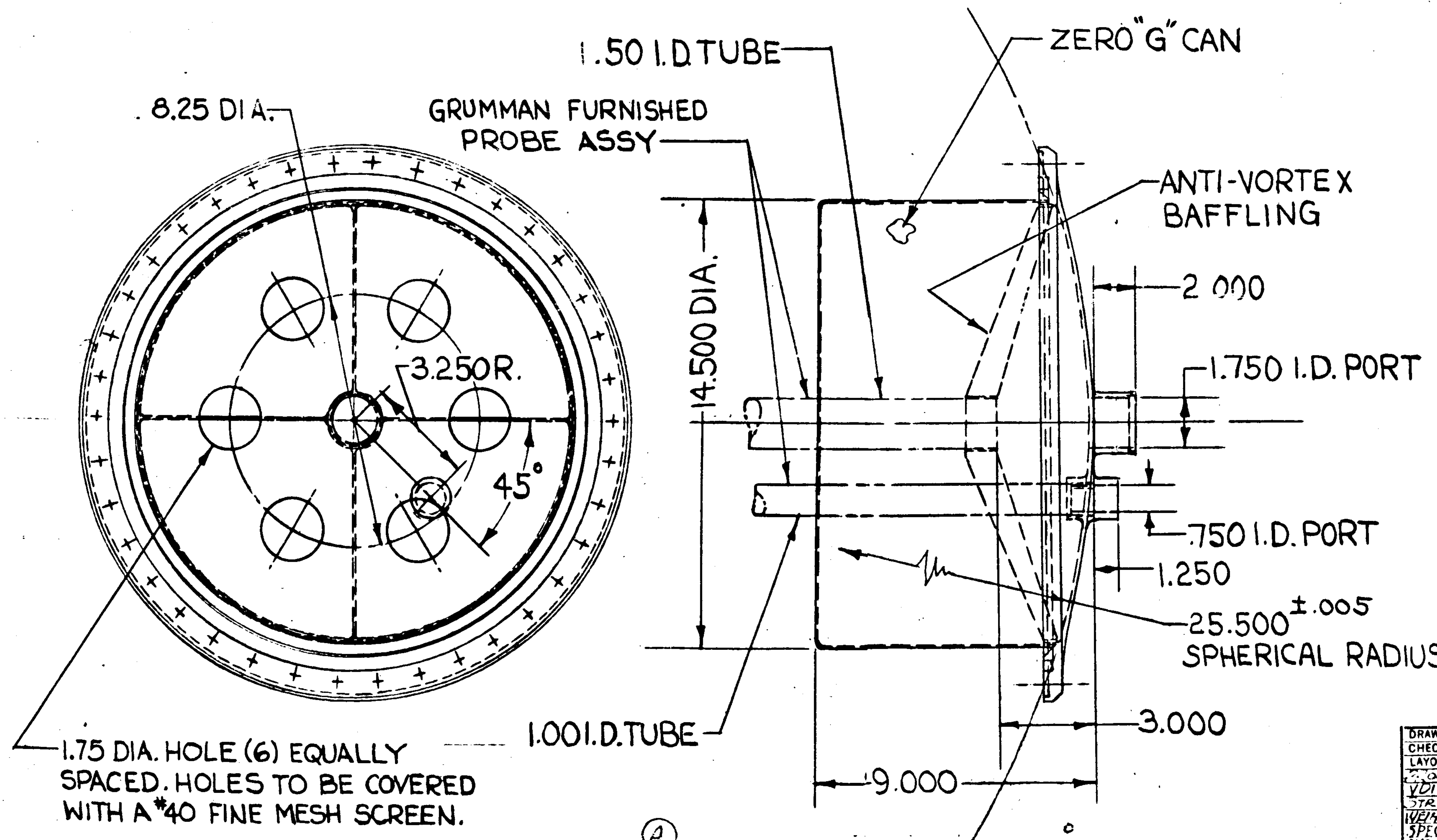
DATE : 7-9-64
PAGE NO.

NOTES:

1. Tolerance on cover thickness to be $^{+.005}_{-.000}$
2. Additional holes and bosses to be established.
3. Surface roughness of machined cover - inner and outer surfaces shall be 63 RMS Max.

REVISIONS

REVISION LETTER	ITEM NO.	ZONE	AUTHORITY FOR REVISION: GRUMMAN INFO ONLY DCRF OR ECP	CLASS II	CLASS I	DET SPEQ REQ	ENGRG ORDER	DESCRIPTION	REVISED BY AND DATE	EFFECTIVE ON MODULE NUMBER	DISPOSITION OF EXIST PARTS: RE-WORK	SCRAP	ENGRG APPD	GOVT APPD
A	1							IN 5/D ADDED -1 AFTER LSC 280-403 & LSP 280-4A	[illegible]				[illegible]	
B	1							LSP-280-4B WAS -4A-1	[illegible]				[illegible]	



LSC-280-403-1 (A)

(B1)
(A1)

SPECIFICATION CONTROL DRAWING
THIS DWG FORMS A PART OF LSP-280-4B CONTROL SPEC.

DRAWN BY	WILSON	GRUMMAN AIRCRAFT ENGRG CORP BETHPAGE, L.I., N.Y.
CHECKED BY	[illegible]	COVER-SUB ASSEMBLY
LAYOUT BY		
[illegible]	[illegible]	
VDI	[illegible]	
STRUCT.	[illegible]	
WEIGHTS	[illegible]	CONTRACT NO. NAS 9-1100
SPECFT	[illegible]	CODE IDENT NO. 26512 — SIZE B — LSC-280-403 B
SYS COORD	[illegible]	
SUB SYS P	[illegible]	SCALE 1/4 — WEIGHT — SHEET